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LECTURES.

Friday, March 14th, 1862.

Colonel Sir GEORGE EVEREST, C.B., F.R.S., in the Chair.

GEODESY;* ESPECIALLY RELATING TO THE GREAT TRIGONOMETRICAL SURVEY OF INDIA.

By Lieut.-Col. Alexander Strange, F.R.A.S., late Astron. Assistant Great Trigonometrical Survey of India.

The Chairman: Allow me to introduce to you Lieutenant Colonel Strange. He has been very much employed in the extensive operations

* I have, in these published Lectures, adhered as nearly as possible to the words in which they were reported by the short-hand writer; they therefore appear couched in language of a more familiar character than that which would have been employed in a written composition. They are also, I am sensible, open to another and a graver objection. The important subject to which they relate is treated in a manner at once loose and incomplete. I am anxious to guard against any misapprehension by pointing out these imperfections, which have arisen from my inability to compress within the compass of two hours anything approaching a full and rigorous exposition of so multifarious a branch of scientific research. I would specify two topics of considerable moment, which I was compelled, by mere want of time, to omit altogether, namely, the determinations of *heights* and of *azimuths*.

Regarding these, I can here only say briefly that the element of height, apart from the interest which more obviously attaches to it, is required for the reduction of all geodesical works to one assumed level—that adopted in India being the mean sea level. The Indian heights have been ascertained, by recent independent investigations, to possess a very high degree of accuracy, and the methods by which they have been obtained well deserved a notice which I was unable to afford them. The azimuth, or direction of the true meridian, is also an element without which no geodesical operation is complete or serviceable. The method by means of which this element is determined in the Survey of India, is only one, but perhaps the most admirable, of those contrived and brought into practical use by Sir George Everest, to whom that department owes all its accuracy of principle and procedure. I believe it is not saying too much to characterise this method as the most perfect solution of a problem known to practical astronomy; but, as it is impossible to give an adequate idea of its elegant precision without entering into details unfitted for an elementary lecture, I judged it best to omit this part of the subject, rather than present it in a loose and mutilated form.—A. S.

of the Great Trigonometrical Survey of India, of which many of you may have heard. They are the most extensive trigonometrical operations that have ever been conducted in this world. India, as you are aware, is not a very small country compared with England and Ireland; and there has been an immense deal of skill and knowledge employed in surveying that country accurately. The survey was commenced in the year 1799 under my master, the late Colonel Lambton. I succeeded him, and I left it in 1843; since that time operations have been going on continuously, and they have been conducted with a great deal of labour, intelligence, and zeal, not surpassed, if they be equalled, in any other country. Colonel Strange has taken an active part in these operations. You may have heard that there has been an extensive series of triangulation carried over that part of the country which extends from Sironj to Kurrachee. It was a very extensive operation, and was carried through (what might be called) *terra incognita*, because, a few years before that time, no European who valued his head would have ventured into those countries. The greater part of this work was executed by Colonel Strange. Operations of this kind, you know, are looked upon by the natives of India with an eye of suspicion, perhaps not altogether unwarranted. They look upon them as a prelude to taking possession of the country, and they give you a gentle hint that you had better take yourself off, if you wish to preserve your head upon your shoulders. I will not trouble you with any further observations, but call upon Colonel Strange to address you.

Lieut.-Col. Strange: It is with very much pleasure that I undertake to give here two elementary lectures on the subject of Geodesy, principally because it is a subject which I believe is very little known to non-professional persons. The word "Geodesy" relates to that branch of science by means of which the size and the form of the earth are determined; the *form* as well as the *size*. To many of my hearers, perhaps, this introductory definition will not have a very promising aspect. It may sound dry, and to savour of technicalities and abstruse mathematical calculations, which, perhaps, to the ladies who have honoured me with their presence especially, may not promise much interest. Yet I am in hopes that they will find, as we go on, something to attract them in it. I can assure them, that, if they are not entertained by this subject as much as by some others which are occasionally discussed in this theatre, it will not be on account of any intrinsic defect in the subject itself, but it will be owing to some defect in the person who is treating of it.

I have said that Geodesy deals with the *size* and *form* of the earth. Now, the first idea that would occur to anybody who undertook to measure the globe which we inhabit would be, that its enormous bulk would alone present a very formidable obstacle to its measurement. Another obstacle is presented by the circumstance that we are on the surface of the globe, and that we can never at one moment get a general view of it. In point of fact, it is easier to determine the size of the sun or the moon, or of many of the planets, of which we can obtain a general view, than it is to determine the size of our own earth. Albeit we cannot determine the size of any of these planets without knowing first that of the earth. Now the earth, speaking in general terms, is about 8,000 miles in diameter. In order to give some sort of idea of this immense body, I will mention one

or two facts relating to it which may assist our perceptions, drawing a comparison between it and this terrestrial globe here, which is about 2 feet in diameter. The highest known mountain in the world, named, after our distinguished chairman Sir George Everest, "Mount Everest," is 29,000 feet in height. To represent that mountain on this globe in its proper proportions, you will have to make it a little more than the hundredth part of an inch in height. It will be a speck of sand, which, at the distance of a few feet, will be invisible altogether to any eye. Take, again, a more familiar object than Mount Everest; take St. Paul's cathedral, which is 404 feet in height. Now that great edifice represented in due proportion upon the globe before you would be the $\frac{2}{10000}$th part of an inch in height, a quantity which would require a powerful microscope for its perception. Compare now these enormous objects, this stupendous natural object,—a mountain 29,000 feet high,—and this great cathedral, one of the greatest of man's works,—compare them with such instruments as we have for the purpose of our measurements, with such, for instance, as you see upon this table, which are not much smaller than those with which the earth is actually measured. The bars that you see before you are just half the size of those with which the greatest geodesical works have been accomplished. This theodolite is certainly smaller than those that are used in first-class operations. It is about one-fourth the size; still multiply that by four, and these bars by two, and then consider what an undertaking you have before you in order to measure this globe, 8,000 miles in diameter, with such appliances.

Besides that of size, there are difficulties presented by the natural conformation of the earth,—by its mountains, its rivers, its forests. Anybody undertaking to measure a room or a road, could, with the use of mere common sense, accomplish his object with a rope or measuring tape, or a rod of wood: he would find it difficult to measure across country with such means, but still he might do it. In fact, measurements have been carried on to a considerable extent by such appliances in linear measurements, as they are called. But when you get to the ocean you are certainly stopped; for it will be impossible to lay bars, or tapes, or rods, or chains along the ocean, to measure, for instance, the width of the Atlantic. Therefore, a direct measurement of the entire circumference of the globe, as generally accomplished by ordinary common-sense people, is manifestly out of the question. Fortunately we have other means provided by geometry. We have the *properties of geometrical figures*, and by their means we are enabled, when we have measured a small portion of a known and determinate figure, to infer the dimensions of the whole.

Now, a circle is one of these. I will introduce the method of employing the properties of that well-known figure, by first supposing the globe to be made up of an infinite number of circles, that is to say, of a form truly globular, which means that it is the same width, the same diameter, in every direction. The terrestrial globe before you represents our earth. Let us imagine this brass ring actually existing in nature, encircling the earth somewhere or other, if we could only find it. Let us suppose, too, that this brass ring has been divided into so many parts, and that marks have been made, or poles have been erected upon it at certain equal distances, and that there are 360 of these poles on the circle encompassing

the earth. That is the number of degrees into which mathematicians divide the circle. It is an arbitrary number; one number of divisions would be as good as another for the purpose we have in view. Let us suppose that this circle has 360 such divisions, called degrees, in it, and that at each degree there is a tangible visible mark; nothing would be easier, if such were really the case, than to determine the size of the globe. Assuming, as we have, that all these marks are equi-distant, we should simply have to measure the distance in feet between any two of them, which would be a small portion of the earth's surface, and multiply the number of feet which we should find between any two such marks by 360; we should then have the circumferance of the circle in feet. It is a very simple problem in mathematics, from the circumference of the circle, to ascertain with any required accuracy its diameter. We should, therefore, by simply obtaining the measure in feet of one degree across a level plain, be able to determine the size of the globe. We owe that facility entirely to the properties of geometrical figures.

We have assumed the earth to be globular. There are good reasons for the assumption. Wherever we go, when we can command a fine, clear, and extensive prospect, we perceive that the horizon is apparently circular. In whatever part of the globe we may be when our view is unobstructed by mountains, trees, or other elevated objects, and particularly at sea, we have a well-marked line defining a circle all round us. Now, it can be demonstrated that such a state of things can only exist on a globular body. Another ground for the assumption is, that in lunar eclipses we see that the shadow of the earth cast by the sun upon the moon is always circular—it is always part of a circle. That also implies that the body casting the shadow is globular; therefore the assumption is apparently a perfectly fair one.

I have pointed out how, by means of marks on the earth, we could, having measured the distance between two of them, determine the size of the whole. But these marks do not exist unfortunately, and we must find a substitute for them. That substitute is afforded by the stars in the heavens. I will endeavour to explain how they are used as substitutes for our hypothetical marks upon the earth. If we go out on a fine night and look at the heavens, and watch them for some hours at a place where we have a clear horizon all round us, we shall perceive (I am supposing that we are in the Northern Hemisphere) that certain stars rise exactly due east of us and set exactly due west; that other stars rise a little to the north of east and set a little to the north of west, and so on till we get to stars more near the north. These we shall find neither rising nor setting, but at all times visible above the horizon, and performing a clear circle round a certain fixed point in the heavens. As we look at stars nearer and nearer to the north we find the circles described by them diminishing, till at last there are some stars the circles performed by which are so small that, without assistance, the eye cannot tell that they are moving at all.

Now, let us suppose the earth to be perforated. The terrestrial globe before you revolves on two points of an iron rod running straight through it, called its axis. Let us suppose that in the direction of this axis the actual earth has a perforation, a hole from north to south through which you may see clearly. Suppose the eye at the south end of this aperture;

looking through, your eye would fall on a certain point in the sky. You would not there perceive any star; nature has not placed one precisely on that spot, as it so happens. But, for the purpose of illustration, we will suppose there is a star exactly in a line with the imaginary perforation. Now, suppose an observer to stand at the North Pole (where no human being has ever stood yet): standing there and looking about him, he will see this imaginary star of ours exactly over his head and immoveable—it will never move at all, day or night, but will form the centre round which all other heavenly bodies revolve. Now, imagine another observer standing on the equator, that is to say, midway between the North and South Poles. Let him gaze about and search for this star, and he will find it, not above his head, as in the former case, but exactly on his horizon. Now, suppose the observer at the equator, on his journey to join his friend at the North Pole, travelling straight along the meridian due north, and watching this star as he goes, he will find, as he advances northwards, that the star will rise; and that, when he gets half-way to the North Pole, the star will be exactly half-way between the horizon and the point above his head. He will go on until he joins his friend at the North Pole, and there they will see the star as before, precisely over their heads.

We see from this that such a star affords the means of informing the observer in what part of the earth he is situated; and it is by means of that information that we are able to substitute for the supposed marks on the earth the stars in the heavens. For I have imagined in this description that there is only one star and that it is in a particular place. There are many stars, as we know, but none there. But what is true of that imaginary star is true of every star actually in the heavens; that is to say, the change of position in the observer produces precisely the same effect or change upon every star in the hemisphere as was produced on our imaginary star. Therefore, any star is sufficient to afford us the means of ascertaining whereabouts we are on the globe; that is to say, of determining our *latitude*, for that is the point to which we have arrived.

Now, supposing that with this knowledge we prosecute our measurement of the globe. We should first determine our latitude; that is to say, we should find at a certain spot on the earth how high above the horizon a particular star stood. We should then go on with our measurement by whatever means; and we will say that we stop when we find that the star had increased its altitude above the horizon just one degree. Instruments are capable of telling us that, and, therefore we can ascertain such changes as those which I am describing. The observer then knows that he has moved one degree of latitude along the meridian, and he knows, from the measurement which we have supposed him to have made, that that degree contains a certain number of feet. He multiplies that number of feet by 360, because there are 360 degrees in the circle of which he has measured only one, and he then has the circumference of the globe, from which it is very easy to calculate its diameter.

We have hitherto supposed the earth to be strictly a globe, strictly of the same width, the same diameter, in all directions. A billiard ball might afford an apt illustration of a globe, or a *sphere* as mathematicians call it. But it was not long that this subject had attracted the attention of learned men before it was suspected that the earth was not a true

globe. Newton, who has laid the foundations of astronomical science, with his extraordinary sagacity perceived that a body revolving on an axis at a certain rate, unless of materials absolutely rigid, must alter its shape; and there were reasons for supposing that the globe had at one time been in a fluid or semi-fluid state. Under such an hypothesis, he argued that the earth could not possibly be quite globular; that the parts most distant from the poles on which it revolved—the equatorial parts—must be made, by the influence of rotation, to protrude beyond what they would do if the mass were quiescent. He was followed in these investigations by Huygens and other great astronomers. The discovery of the telescope took place about that time, one of which, made by Huygens, was 123 feet long; and with the aid of this wonderful instrument he perceived that the body of the planet Jupiter actually was not globular, but that it was wider in its equatorial parts than in its polar. This afforded an argument of a species which has always had an enormous influence on the human mind, the argument by analogy. Arguing from analogy, the conclusion seemed irresistible that the earth was not globular, but that it was of that figure which mathematicians call an *oblate spheroid;* that is to say, of a form such that the distance between the two points round which the body revolves is less than the distance between the two at right angles to them, in other words, the polar diameter less than the equatorial diameter.

I have said that in measuring a true globe or sphere it is only necessary to measure one degree, and that, with the knowledge of one degree, we can attain to the knowledge of the whole. But that is not true of the *spheroid.* A section of the solid body so called is represented in fig. 1, and is a figure called the *ellipse.* It is not true, if we measure a single part of that figure, that we shall be able to say we know the whole; because all its parts are not equi-distant from the centre, and the degrees will not be of equal lengths in all parts of it. We may consider an ellipse, for our present purpose, to be made up of an infinite number of circles differing in size. Referring to the figure, in which the dark line represents an ellipse, we see that a small circle ABC, whose centre is X, coincides with the ellipse at A; a larger circle DEF, whose centre is Y, coincides with it at E; and a larger still GHI, whose centre is Z, coincides with it at H. The spaces between these circles might have been filled up with others, gradually increasing in size, from A the most, to G the least, curved part of the ellipse, to any number, until at every point of the ellipse a circle was adapted to it. We may consider the ellipse, then, to be composed of an infinite number of circles differing in diameter; and any part of it may be dealt with (that is, if it be a small part) as a portion of a circle.

Referring now to fig. 2, we have two circles, whose centres are respectively X and Z, coinciding with the most and least curved part of the ellipse. On each of these circles an angle of 20° (any angle will do) is laid off,—precisely the same angle in both cases. These angles intercept respectively the arcs AB and CD of the ellipse. We see, however, that the arc CD at the flattest part of the ellipse, which may be considered to represent the pole of the earth, is much longer than the arc AB at the most curved part of the ellipse, which represents the earth's equator. Now these arcs are in fact arcs of a meridian, and CD a difference of latitude of 20° at the pole, whilst AB is a difference of latitude of 20° at the

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Pl. 1.

Fig. 1.

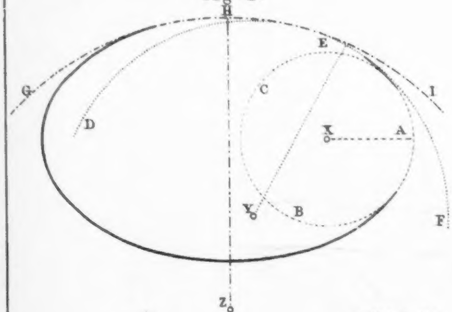


Fig. 2.

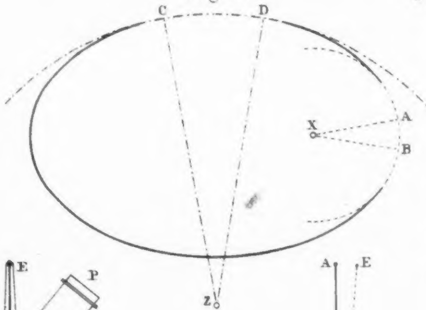


Fig. 4.

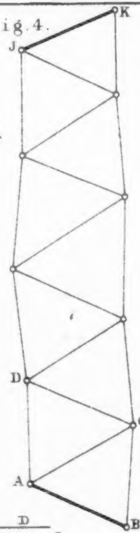


Fig. 12.

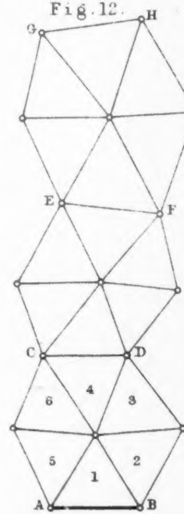


Fig. 3.

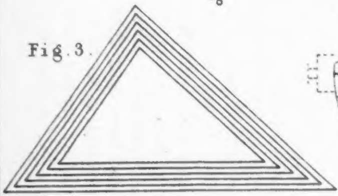


Fig. 14.

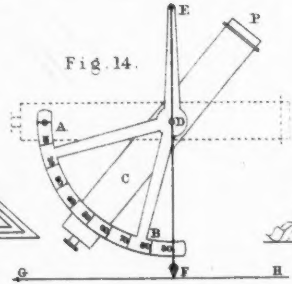


Fig. 15.

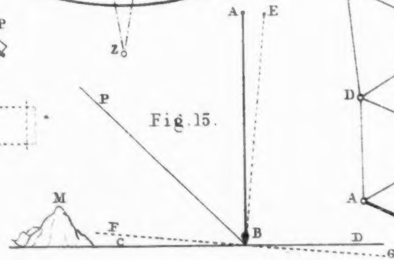


Fig. 13.

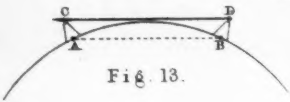


Fig. 16.

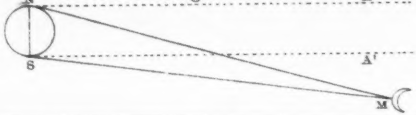
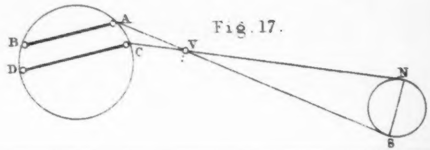


Fig. 17.



J.R. Jobbins.

equator. But it is evident that, at the pole, that difference of latitude corresponds to *a greater number of feet* than the same difference of latitude at the equator. In the figure the ellipticity or flattening of the earth has been much exaggerated for clearness' sake.

If then, in practice, we find, at or near the pole, that one or any number of degrees of latitude contains the same length in feet as the same number of degrees of latitude at the equator, we may conclude that the earth is truly spherical. But if we find that the degree at the pole contains more feet than the degree at the equator, we shall know that the earth is not a true *sphere* but a *spheroid*, and that is precisely what we do actually find. This, therefore, is another example of information indirectly obtained from the *properties* of geometrical figures.

Thus it is apparent, that to measure a true globe or sphere *one* measurement suffices; but to measure a spheroid *two* are indispensable. Yet, though two measurements suffice, theoretically, even for the determination of the spheroid, there are practical reasons for multiplying the experiment, to which I shall not at present allude. Many such measurements have accordingly been made. One in Peru, measured many years ago, was one of the very first executed. It is very near the equator, and, therefore, very valuable. For it is evident, from the inspection of figs. 1 and 2, that the further apart we get the two measurements the better; that is to say, the nearer we get one to the pole, and the nearer we get one to the equator, the better, because the difference between them is then the greatest possible. The measurement in Peru, on the west coast of South America, is, therefore, a very valuable one indeed, because it is on the equator. There is also an arc measured in Sweden, from the North Sea through Russia down to the mouths of the Danube. There has also been one measured in Italy. There is also a very valuable one in France. There has also been one at the Cape of Good Hope, which was measured by the celebrated French astronomer La Caille, whose work our Chairman subsequently revised. There has also been measured an arc of meridian of great importance in India, regarding which I may justly say, and I think without any impropriety, as I had nothing to do with the execution of that particular arc, that it has no equal for accuracy in the world.

Now, having got so far, we see how, by ascertaining the number of feet, and by knowing the difference of latitude between the two ends of the measurement, we can tell the size and general form of the globe. But how are we to make that measurement?

I think very few people will persevere in the attempt to do it in a straight line by means of rods, chains, &c. Such a thing has been done. Such a direct linear measurement, about 100 miles in length, was executed in 1764, along the peninsula between Chesapeak Bay and Delaware Bay in North America, by Messrs. Mason and Dixon, under the auspices of the Royal Society. It was for the purpose of determining the boundary between Maryland and Pennsylvania. They measured with rods in a straight line, and this is the only work of the kind ever executed in that way. The country was favourable. There are very few parts of the world where such a thing could have been done without enormous expense; therefore, direct linear measurement seems to be out of the question in most cases. Now, there is another method which I am aware is well known to many of my audience; but in the sketch which I am giving of these matters

(and time does not admit of more than a sketch) I have been anxious to make myself intelligible to those who are less acquainted with such topics, as I wish them to be as much interested in the subject as my more learned hearers. There is then another method of executing measurements on the surface of the earth called triangulation. A triangle is composed of six parts, evidently. There are three corners or angles, and three sides. Now, if we know the three angles, that is to say, if we know how much the opening at each corner is, we shall know the exact *shape* of the triangle. But we shall not know its *size*, because we can draw a smaller triangle within the first triangle, having precisely the same angles, but sides of very different length. This will be what mathematicians call a *similar* triangle. There may be an infinite number of triangles of that *shape*, all differing in *size*, as in fig. 3. To determine the *size* we must know the length of one side. There is no other way of doing it. It is immaterial which, but one side we must know, and knowing one side, and any two of the other five elements,—either the other two sides or two of the angles, we can then calculate rigorously the *size* of the triangle, that is, the respective lengths of its sides. This is a very simple problem in trigonometry, on which, however, a great deal depends.

To carry on a measurement of the kind about which we are speaking, and which is illustrated in fig. 4, we require first of all to measure the length of one side of a triangle. This side or line is called the *base*. We will suppose the dark line AB to be the base measured in some way—I will describe how presently—that we know its length precisely in feet and inches with the greatest accuracy. Then with instruments called theodolites, such as those on the table, we can measure the size of the angles CAB and CBA. We then have sufficient data to enable us to calculate the length of the two remaining sides of the triangle, viz. BC and AC. That is a very important piece of knowledge to have gained, because the side AC forms a side of the next triangle ACD, and further linear measurement is no longer necessary; the side whose length we have obtained by calculation is as accurately known as if it had been measured. We know then this side AC, and can measure the angles connected with it as before. We can then calculate the sides AD and CD of the next triangle, and so on. I need not go on repeating the process, it is the same thing for each triangle; the power to calculate the sides of these triangles is transferred from one to the other, and there is scarcely any limit to the distance to which triangulation may be thus carried on from one measured base line.

You have here two operations,—the linear measurement of the base, and the measurement of the angles of a chain of triangles. The third operation is the determination of the latitude at the two ends of the triangulation, which I have supposed to run north and south.

Now, that is the way in which the globe is actually measured. A point is fixed upon. A base is measured there on fine open ground, and its latitude is determined astronomically. Triangles are then selected. Their angles are measured with the theodolite, several hundred miles being sometimes traversed by the triangulation. When a convenient point has been attained, north or south of the starting-point as the case may be, the latitude is again determined. Then the difference between the two latitudes shows us what proportion of the earth's circumference we have traversed; and it is very easy, with a knowledge of the length of all the

sides of the triangles, to ascertain the total length of the whole chain. We then know that a certain number of degrees, that is, a certain fraction of the earth's circumference, contains a certain number of feet. This is the result of which we were in search; and it is deduced as correctly, I may say even more correctly, by a measurement made by means of triangles than if made in a direct line with rods.

The measurement of the base is a most important operation, as it is evident that if that be not correct no calculations founded on it can be so. I do not think I am wrong in saying that it is the most delicate and difficult operation known to science. There is no operation in which so much delicate manipulation and such a knowledge of the properties of matter is required as in the measurement of a base line suitable for such objects as we are considering. Accordingly an immense amount of ingenuity has been bestowed upon the subject. Different savants have used different appliances. In the English Ordnance Survey they commenced with wooden rods and wooden frames having very delicate adjustments; they then tried glass rods; they then tried steel chains. All these have been tried: it would take up the whole of the time allotted to me if I were to attempt to describe them. I must, therefore, press forward to the last apparatus contrived in England for making such measurements, of which I beg to show you a model. The subject, I have said, is full of difficulties, and one of the first and greatest is that which arises from the power of changes of temperature to cause the expansion and contraction of every form of matter with which we are acquainted, particularly of metals. Glass rods expand and contract, although very slightly; wooden rods also alter their dimensions, but from causes different from those which act upon metal, and in a less regular manner. It is evidently most important that we should be able to know hew much the rods expand and to make due allowance for the error that would creep in from that cause; because, although the operations that I have been describing are, compared with the smallness of our means, very large operations, still, compared with the size of the earth, they are very small, very minute, indeed. And what we have to apprehend is, that, in making an error in a small part of the earth, that error will be multiplied a great many times before we arrive at the entire size of the earth. To illustrate this let us suppose that I make the measurement of a base with a rod ten feet in length, and that at every rod I make an error, from whatever cause, of only the one-hundredth part of an inch; this, by the mere process of multiplication, would cause an error in ten miles of four feet and a half; in the diameter of the earth it would cause an error of 3500 feet; and in the circumference of the earth it would cause an error of nearly 11,000 feet, or more than two miles, and that arising only from an error in each rod very little more than twice the thickness of a sheet of paper. Hence, it is apparent that the operation in question is a very delicate one indeed.

I cannot enter into all the causes that may introduce error in such measurement. The chief one, as I have said, is expansion. I will now endeavour to explain the form of apparatus which has last been employed for overcoming this difficulty. This apparatus is the invention of the late Colonel Colby of the Royal Engineers, and it is well known in the

scientific world as "Colby's Compensating Base-line Apparatus." It is with this apparatus that all the later bases of the Ordnance Survey, and all those of the modern portion of the Indian Survey, seven in number, have been measured.

I should here explain that I have placed this apparatus in a sloping position in order to make it more visible to the audience, and that, when in use, it rests level. I should also explain that, for want of room, I have been obliged to have the model made half the real size. In actual use these bars are ten feet long. Now you see here, fig. 5, two bars, AB and CD, connected in the middle immoveably by a block of metal E, and carrying at their extremities two tongues (as they are called), F and G, at right angles to them. At the extremity of each tongue there is a small dot. In the real apparatus there is a piece of platinum let into each tongue: upon the platinum is made a very minute dot with the finest needle, so minute as to be scarcely visible to the naked eye. The problem requires that these two dots should remain always the same distance apart, in this model five feet, and in the real apparatus ten feet. The bars are represented in fig. 5 in what I may call their normal state, that is, at a certain temperature agreed upon, say 62°; the tongues are exactly at right angles to the bars, and their dots are exactly ten feet apart. Now, the temperature of the air is constantly changing, and it cannot change in the slightest degree without altering the dimensions of almost everything in the world, and particularly those of metals. Accordingly, these bars expand as they get hotter, and the tongues, which before were exactly ten feet apart, become now, under this change of dimensions in the bars, wider asunder, as in fig. 6. That is what would happen if both the bars were made of the same kind of metal. Such a defect would be fatal to our measurement. But by an ingenious arrangement that defect is corrected.

Though all metals expand by heat, all do not expand equally. For a given increase of heat brass expands more than iron, in the proportion of about 5 to 3; that is, the same amount of heat which would make a brass bar expand 5 inches would make an iron bar expand only 3 inches. Taking advantage of this peculiar property of the two metals in question, the bar AB furthest from the dots is made of brass, and CD, that nearest to the dots, of iron. The tongues are not rigidly connected with the bars, but have pivots at a and b (*vide* fig. 7 on a larger scale) which admit of slight play. The length of the tongues is an important matter. Referring again to fig. 7, the proportion between $a\ c$ and $b\ c$ must be the same as the proportion between the expansions of the two bars, namely, as 5 to 3; in other words, if $a\ c$ is 5 inches then $b\ c$ must be 3 inches.

The effect of these arrangements is shown in fig. 8. The iron bar CD is in the same state of expansion from heat as in fig. 6, but, whilst the iron bar has been lengthening so much, the brass bar has lengthened more, and the two bars being now different in length, the tongues are compelled to assume an oblique direction, which brings the dots at their extremities to exactly the same distance apart, viz., 10 feet, as at first in fig. 5. What is true of the expansion of the bars by heat is equally true of their contraction by cold, so that, if the proportions have been carefully attended to, the dots at the extremities of such compensation bars should always remain

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Pl. 2.

Fig. 5

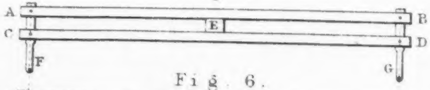


Fig. 6.

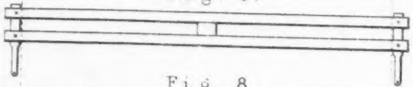
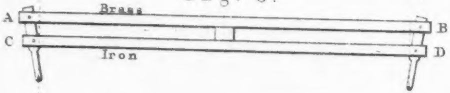


Fig. 8.



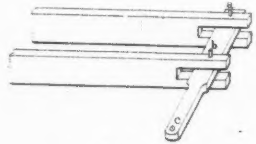


Fig. 7.

Fig. 10.

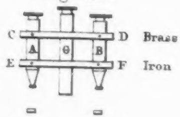


Fig. 9.

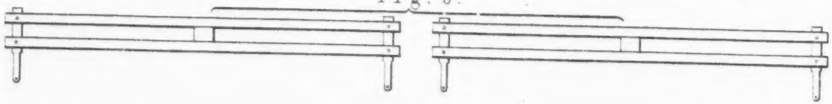
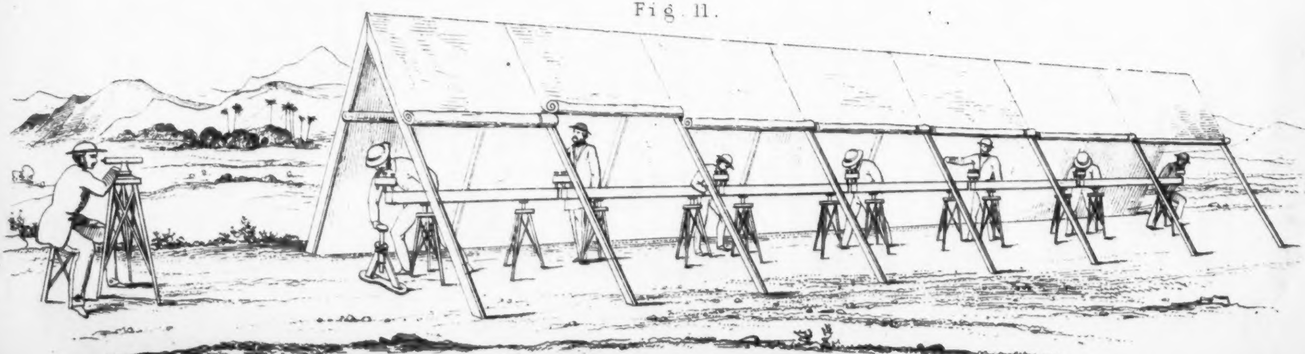


Fig. 11.



MEASUREMENT OF A BASE-LINE,

sensibly at one and the same distance asunder. The expansion of the bars and the consequent obliquity of the tongues has been greatly exaggerated in the figure for the sake of clearness.

There remains still another requirement. The measurement is carried on, not with one such compensation bar, as we have described, but with several placed in a line. But there will be a very perceptible interval between the dots on two adjacent bars, as in fig. 9. How is this interval to be filled up? In this manner: Two powerful microscopes A, B, fig. 10, are connected by means of two bars CD, EF. These bars are, one of brass the other of iron, and the length of the microscopes is proportioned to the expansions of the bars, exactly as the tongues were in the case just described. This counteracts the effects of expansion in their case also, and keeps them always at an effective distance apart of 6 inches. A fine cobweb is fixed in each microscope; one microscope is placed over the dot at the extremity of one of the 10-foot bars, and the next bar is then moved up until its dot is under the other microscope, and, the dots being made to coincide with the cobwebs of the microscopes, they must be exactly 6 inches apart. All the bars, of which six are usually employed, are thus optically, as it were, linked together.

The compound bars which have just been described are those which are used for measuring the base, but it would not do to trust to their preserving the same length under all circumstances, as they are subject to a great deal of handling. There is accordingly another bar laid apart expressly for the purpose of testing these measuring bars. It is a bar of iron with very fine dots upon it at its extremities, 10 feet asunder, and it is ascertained how much that bar expands for one degree of Fahrenheit's thermometer—a most delicate operation,—but when once accomplished it is supposed to stand good for ever. Then in the course of the measurement of a base the compensating bars are frequently compared with the standard, and the length corrected thereby, due allowance being made for changes in the standard caused by temperature.

Fig. 11 is a sketch showing how the measurement is actually carried on. These bars, which you now see in the model and figures exposed in order to explain their construction, are in reality encased in long wooden boxes. In practice we use six such bars. Any number might be used, but that is found to be a convenient number. There are six bars and six pairs of microscopes; therefore, the bars being 10 feet and the microscopes 6 inches, the total length of the whole apparatus when put together is 63 feet. You see in the sketch, beginning at the left, first, a bar with a pair of microscopes at the end of it; then we have another bar and another pair of microscopes at the end of that; then another bar and another pair of microscopes, and so on with the whole six. There is an observer at every pair of microscopes, and all these observers act in concert. You must suppose the measurement to be proceeding in a direction from left to right. The first thing to do is to prepare the ground, which is selected as level as possible, and as free as may be from watercourses, swamps, and inequalities, and generally from six to eight miles in length. It is then cleared, and a sort of path made along it, the straightest that can be made, and the vegetation carefully removed in order that the instruments may stand on the solid earth and not be subject to the tremor which would occur if they stood on

roots and grass. Then a special party is appointed to lay out the base along the centre of this ground, in as straight a line as they can make it. They place on this line the supports for the bars, trestles, each bar resting upon two, as may be seen in the sketch. Then another party is detailed to carry the tents; for an apparatus of this sort would be very difficult to use indeed if subject to the heat of the direct rays of the sun, which are never allowed to fall upon it when in use. There are, therefore, tents over the bars. There are two sets of tents, in order that there may be one set ready for the moving on of the bars. The bars then have to be levelled; they are placed upon the trestles. These are provided with a very ingenious brass apparatus for levelling the bars and placing them truly in line. Each bar is levelled; it has three levels for the purpose. Each pair of microscopes is also levelled; then each bar is aligned by the observer (represented at the left of the sketch) with an instrument somewhat like a theodolite, contrived expressly for the purpose, and called a "boning instrument," by means of which he informs any man in charge of a bar whether his bar is to the right or to the left, and they are, with his help, brought mathematically into the same line. Then the man at the rear microscope starts from the point denoting one end of the base—usually a fine dot made in metal imbedded in stone,—he looks at it through the central telescope fixed between his microscopes (G in fig. 10); he moves the bar with the telescope attached to it until the dot fixed on the ground is exactly in correspondence with the spider wire of his telescope. Then the other men move up their bars till the optical connection is made in each case, in the way that has already been described, the aligning and levelling being also maintained correct. At last it is all satisfactorily settled, and the man at the last microscope (at the right of the sketch) adjusts a dot on a solid moveable cast-iron stand, called a "register," exactly under the wire of his telescope. When that is done the bars are taken up, and the dot, which has just been fixed by the man at the right of the sketch, becomes the starting-point for the next set of bars. In that way the measurement is carried on, as it might be, with a pair of gigantic compasses 63 feet long. A system of regular drill and word of command regulates the whole operation, which is more like a military movement than a scientific undertaking.

The base line having been measured, the triangulation is then proceeded with. The instruments are set up at the extremities of the base, and the angles are measured. The importance of accuracy in the measurement of the angles is of course extreme, as the smallest variation in the angles will alter perceptibly the lengths of the sides which compose them. And, if the lengths of the sides are altered, the total length of the whole chain will be wrong. Therefore, very large and delicately-contrived instruments are constructed for the purpose of measuring these angles. The instrument with which the great meridional arc in India was executed had a circle thirty-six inches in diameter; it had a telescope four feet long nearly: it had the most delicate appliances for regulating every part; and it was so ponderous that it took twenty-four men to carry it. That instrument had to be carried up the highest mountains, across rivers and deserts, wherever the necessities of the triangulation decided that it must go.

We call a chain of triangles a "series." A series may be of two kinds, a *single* or a *double* series. Fig. 4 represents a single series, the arrangement of which is very evident; fig. 12 represents a double series. This may look a little more complex, but it is also quite simple when analysed. In the first, the single series, we deal with each triangle separately; in the other, the double series, we treat the triangles as components of the compound figure into which they enter, and deal with each such compound figure independently, completing the calculation of one figure before we proceed to calculate the next. In fig. 12 we have a chain of *hexagons.* In calculating these we have the means of improving and checking our result, by obtaining two independent values or lengths for the sides CD, EF, and GH, which connect the hexagons, and which are called *sides of continuation.* For, starting from the side AB, which we suppose to have been measured, we can calculate the triangles 1, 2, 3, and 4, round by the right, and so deduce the length of the side of continuation CD; this is one value: we can then, starting as before from the side AB, calculate the triangles 1, 5, 6, and 4 round by the left, and so deduce a second value for the side of continuation CD. The two lengths so obtained, in good work, often agree; but there is sometimes a trifling difference, in which case the mean of the two is adopted, as being probably more correct than one would be. Having thus obtained a good value for the side of continuation CD, we employ it as the base with which to calculate the next hexagon, and so on throughout the chain. Though our calculations are not conducted exactly in this manner, the above will serve to show how a double series serves to check the work. Other figures, besides hexagons, such as pentagons, heptagons, and quadrilaterals, are also employed in a double series. The modern works executed in India, since Sir George Everest introduced his system, have almost invariably been executed with a double series. The system entails more difficulty in laying out the triangulation, and a greater amount of labour, but it greatly diminishes anxiety by affording very satisfactory proof, as the work proceeds, of its exactitude.

I will not detain you much longer. I have one point more to dwell upon, and then I have done for to-day. When our triangulation crosses hills we are, as it were, surveying *on velvet.* We have there natural eminences from which we obtain a fine and distant view; we are placed in a pure atmosphere, and our signals are easily seen. It is a very agreeable work, indeed, to carry on in a fine country, if there are hills. If there are plains it is different. A very great portion of Sir George Everests's triangulation in central India was across extensive plains, where the country is one dead monotonous level for hundreds of miles. Under such circumstances we are placed in a dilemma. Let fig. 13 represent a portion of the globe; let A be a point selected for the end of one of the sides of the triangles; let B be another at the other extremity of that side. Now, it is perfectly evident that these two points cannot be seen from each other, as they should be, because the rotundity of the earth intervenes. We are therefore constrained to build at each point a tower; and the observer, with his instrument C placed on one of the towers, can then see an object D placed on the other. In the plains, therefore, at the extremities of every side of each triangle, it is necessary to erect massive towers, from 30 to 150 feet high, according to circumstances, and of such

proportions as to fit it to bear many observers, six or eight men, a considerable tent, and the large ponderous instrument of which I have spoken, and capable of bearing all that weight with the extreme immobility required for taking excessively delicate observations. This adds greatly to the difficulties, the anxieties, and the cost of the work.

I shall not dwell now upon the method in which the latitudes are determined, as it would occupy too much space; but they are determined by astronomical means. Sir George Everest, in order to ascertain what difference of latitude there was between a point near Beder, a well-known town in India, and a point near the foot of the Himalayas, took observations with two magnificent instruments simultaneously. There was a party of observers at each instrument; and they observed the same stars at the same moment, thereby excluding many sources of error. Two thousand seven hundred and forty-eight observations were taken to ascertain the difference of latitude between those two points only. I may unhesitatingly assert that no geographical element is so well known as the difference of latitude of the extremities of that arc. I can say this, for I had nothing to do with it; I entered the department after that operation was completed.

The result of operations such as those which I have attempted to describe, carried on in different parts of the world, is simply this: We come to the knowledge that the earth, instead of being globular, instead of being a true sphere, is a little flattened. It is less in diameter between the north and south poles than it is in a line passing through the equator. That difference may be represented by the fraction one-three-hundredth nearly ($\frac{1}{300}$). The equatorial axis is to the polar axis as 299 to 298; not a great difference it is true. The equatorial axis is in miles 7925 and rather more than a half, the polar axis is a little more than 7899 miles. The difference, therefore, between the two diameters is a little less than 25 miles. It is not considered that the enormous labour which is implied by various measurements that have been made in different parts of the globe, of which the above is the result, has been thrown away. On the contrary, more measurements are required to ascertain with still greater accuracy this point. Though there is so little difference in length between the two lines defining the earth's dimensions, still that little difference is of immense importance to astronomy. And the men who have exhausted their strength and bestowed their whole mind upon this subject in order to arrive at what appears but a few insignificant figures, truly deserve well of their fellow-men.

The Chairman: You will agree with me that we ought to return our thanks to Colonel Strange for the luminous and interesting account he has given us of a very difficult subject. To make such a subject interesting at all shows great skill on the part of the lecturer. Very few people could accomplish so arduous a task; for mathematics are, generally, a very dry subject, and it requires a particular talent to be able to overcome that dryness. We return our thanks to Colonel Strange.

Colonel Strange: I am much obliged to you for the kind way in which you have received my remarks. I beg to inform you that the subject, which is by no means completed in this lecture, will be resumed next Friday.

Friday, March 21st, 1862.

COLONEL SIR GEORGE EVEREST, C.B., F.R.S., in the Chair.

LT.-COL. STRANGE: Sir, Ladies, and Gentlemen.—In the lecture that I had the honour of delivering here last week, I made the assertion that Geodesy is a subject very little known. I wish to justify having done so, as I do not desire it should be thought that geodesists arrogate to themselves any superiority over other scientific persons, or that we claim for our science greater difficulties than belong to all sciences. The fact is, that any branch of science cultivated to the point of perfection, or even to a point near perfection, must be surrounded with difficulties. I believe all, considered in that sense, are equally difficult. Nor do I pretend to say that the scientific investigations we are now considering are more important than other physical or mathematical researches. The various branches of science are only parts of a great whole. They relate to a knowledge of the works of creation; and, as such, every part is of equal importance with its fellow part. But I have to explain why I said that Geodesy was little known, and how it comes to be little known. We see amateurs distinguishing themselves in different departments of science,—in natural history, in chemistry, in geology, in mechanics, in astronomy. We know that, provided the skill be adequate, and the resolution to succeed strong enough, a great deal may be done in science, even with very small means. We know that some of the greatest facts in chemistry, for instance, have been determined and placed on a footing that cannot be shaken, by Woollaston and other great men, with means that in these days would be called the rudest. Woollaston worked with a few wine-glasses and test-tubes. We know, too, that in astronomy private individuals have erected observatories, and have rendered great benefit to science by their discoveries and researches. I need only mention Lord Rosse's name, Mr. Groombridge's, Mr. Lassells's, and Dr. Lee's, to show that an amateur may vie in the excellence of his results with even professional establishments. But there is this difference between Geodesy and most other branches of science—that it cannot be prosecuted with small means, and that I believe is the reason why it is so little known. Geodesical operations are necessarily carried on upon a large scale. I spoke to you of measuring degrees of the meridian, not one degree, but many degrees, traversing hundreds of miles. Such operations require a large force of men, most expensive instruments, and the whole maintained for many years. They also require that free access should be given into the dominions of adjoining nations. Political considerations, therefore, are brought into action. The result is that it is a branch of science closed to individuals, and which can only be prosecuted by the resources of a state. That is the reason, I apprehend, why so little is known of Geodesy. And as there are no private cultivators of the science, and therefore but a small demand for its literature, the books that treat of it are, almost without exception, of a dry professional character.

I think, before entering upon any new matter, I ought to recapitulate

briefly what I laid down in my first lecture. I first showed that the earth, if a true *sphere*, can be measured by means of one geodesical arc. I then showed that, for a *spheroid*, which it is, two arcs are absolutely indispensable. I also showed that each arc consists of three distinct parts—two latitudes, one at each end, the base, and the triangulation. I did not dwell particularly upon the necessity for ascertaining that such operations are accurate; nor did I touch upon the tests that are applied to them for the purpose of ascertaining their accuracy. There are principally two tests which are applicable to such works. These tests, like almost every other test in science, are but relative. The first test is the *triangular* test; the second is the *linear* test. The triangular test is this: it is a fact, capable of the strictest demonstration, that the three angles of a plane triangle, that is to say, a triangle described on a perfectly flat surface, if added together, are equal to 180 degrees, or two right angles. When described upon a spherical surface they are equal to that, with the addition of a small quantity, easily determined, called the "spherical excess." Now, here we have a means of ascertaining whether the three angles which we have measured with our theodolite are, when summed together, of the right amount. They should equal 180 degrees, plus a small quantity, which is generally not more than two or three seconds; but, small as it is, it must not be disregarded. Now, this test only shows that the *sum* of the three angles is correct. It does not show that *each angle* is correct, and that must be borne in mind. It is there that the test fails; and it is there that we have no test but that of inference.

Now, applying this test to some works with which I am most familiar, we get this result. In the northern part of the great meridional arc of India, which commences at Beder and ends at the foot of the Himalayas, there are 152 triangles, and it is found that the difference between the sums of the angles of these triangles and the number which they should represent, that is, the average error of all those triangles, is not quite nine-tenths of a second. Now, a second of arc is a quantity so very minute, that very few, I suppose scarcely any but professional persons, have ever appreciated it. The average of this great work gives an error of about nine-tenths of a second. If we distribute that equally between the three angles, then the average of the angles may be inferred to be true within three-tenths of a second, which is an excessively minute error.

Another work, the greater part of which I had the honour to execute, was the "Great Longitudinal Series," which commences at Seronj, in Central India, and terminates at Kurrachee in Scinde. It is about 670 miles long, and it contains 173 triangles. The triangular error was a fraction less than what I have just stated, showing the great consistency in these operations, carried on, as they all are, on the same system. That is the *triangular* test, and when applied to a large number of triangles it is a very trustworthy test. But still, as I have observed, it is not conclusive with respect to any one angle.

The linear test is different. I purposely avoided, in my first lecture, referring to the fact, that, in all geodesical operations, it is usual not only to measure a base line at the commencement of an arc or series, but also one at its termination. Both are represented in fig. 4 by the dark lines AB and JK. The reason for having two base lines measured is very

simple. The operations, we will say, commence from the base AB, which is called *the base of origin*. The triangles are carried on northwards, and computations are made of the lengths of the sides of every one of the triangles of the chain, extending in some cases over six or seven hundred miles without a single linear measurement being made, that is to say, a measurement of feet and inches, not one; until, in a favourable locality, another base line, JK, called the *base of verification*, is measured, corresponding with the side of one of these triangles. If there is any important error in the work, it will be found that the length of the side of that triangle given by the calculation, and the length of the same side given by the actual measurement, will differ considerably. This is the *linear* test. It generally exposes a small want of agreement even in the best works.

Now, in the work in which I was engaged, it was found that the verification in question, at the end of the work, assigned a discrepancy to the amount of one inch and nearly two-tenths per mile of that work, that is to say, that every mile in the work, instead of being exactly one mile, was one inch and two-tenths less than a mile. In the great meridional arc the errors were even smaller. In the northern section of it, from Seronj to Dehra, at the foot of the hills, the error was only nine-tenths of an inch per mile. In the southern portion, which I think I may say stands without an equal in the world as a geodesical performance, commencing at Beder, and terminating at Seronj, the error was only five-tenths of an inch—half an inch per mile. Now, let any body go into an open plain and set up two fine marks representing a mile, and then by the side of that half an inch, and he would then have some idea, by comparing these two quantities, of the extraordinary accuracy attending these operations.

Then, though that tests the work, it does not test the bases themselves, They may be erroneously measured. We have the means of testing them, into which I cannot fully enter. But one of them consists in the remeasurement of the base. You naturally assume, if you perform the same operation twice and arrive in both cases at nearly the same result, that in both cases your work has been well executed. A base was measured at Dehra, at the foot of the Himalayas, by Sir George Everest, and it was re-measured. It was about seven miles and a half long. The first measurement and the second measurement were taken in very different seasons; it was very much hotter during the one measurement than during the other—a severe trial to such an apparatus as was used. The result was that the two measurements differed, that is to say, the seven miles and a half in the one case and in the other differed by two inches and three-tenths. That error, Sir George Everest, in his work on the subject, with great justice, presumes to have been in some degree caused by the compensating apparatus which I alluded to in my last lecture not being perfectly compensated, for the direction of the error coincided with the increase of the temperature. It is a curious fact regarding this apparatus that it is not found to be permanent in length. It has now been in use twenty-five years; it has been constantly compared with the standard bar; and, though the six measuring bars added together never did exactly equal the standard bar multiplied by six, that is of no consequence, provided we know how much the difference amounts to. But the difference should be permanent, it should be the same at all times in a

given temperature, and it is not found to be so. It is found to have increased in the course of twenty-five years by about two-hundredths of an inch —a quality which is made so clearly perceptible that there is no question whatever about it. And the only question that remains to be decided is, Has the standard bar shortened, or have the compensation bars lengthened? That is a question which I believe science is unable at present to answer decisively.

Now, I mentioned in my last lecture that many arcs had been executed in different parts of the world. The question may naturally arise— having measured two arcs, with which theoretically the form and size of the earth can be ascertained—why measure more? There are two reasons for it, two particular reasons. One is this, that we cannot be certain that the earth,—although we know it in general terms to be what mathematicians call an oblate spheroid,—we cannot be certain that it is quite symmetrical, that all sections of the earth through the poles will in every instance give a perfect ellipse of the same size. There may be parts where the ellipse bulges more than in others, and other parts where it flattens; and it is reasonable to apprehend that such is the case, because we do not suppose that the earth is of the same density throughout, a condition indispensable to symmetry. The causes which made it elliptical, namely rotation in a semi-fluid state, may have made it unsymmetrical. That is one reason. The other reason is that the absolute latitude, determined astronomically, is subject to one source of great uncertainty. Newton laid down the law of universal gravitation, "That every particle of matter in the universe attracts every other particle with a force directly proportionate to the mass of the attracting particle, and inversely to the square of the distance between them." That is to say, that everything in the earth tends towards every other thing, that the tendency of one object to attain to another is dependent partly upon the weights of the two objects and partly upon their distance asunder in the mathematical ratio which I have just stated.

I said in my first lecture that the latitude is equal to the angular elevation or altitude of the pole above the horizon. But what is the horizon? At sea the horizon is a well-defined circle round the observer, and it is easy to conceive that the altitude of the pole (supposed a visible point in the heavens) may be measured by taking this circle as a fixed point from which to measure. But on land we have no such defined horizon—mountains, trees, &c., intervening, or haze obscuring our view. On land, then, we must have recourse to other means; and accordingly we use the spirit level or the plumb-line for the purpose of indicating where the horizon would be if visible. The plumb-line, though now seldom used in astronomical instruments, will best serve our present purpose of explanation.

In fig. 14 let AB be a metal quadrant graduated to degrees from 0° to 90°; C a telescope moving round the centre, D, of the quadrant, in a vertical plane; EF a plumb-line suspended from a support forming part of the instrument; and GH the plane of the horizon, supposed not visible. The property of the plumb-line is to hang in a vertical direction, that is, perpendicular on all sides to the horizon; in other words, the angle formed by the plumb-line and the horizon is a right angle, or 90°.

It is evident then, as we know the angular relation between the plumb-line and the horizon, that the former may be substituted for the latter, and so employed on land when the horizon is not available. Hence, if we adjust our quadrant so that the plumb-line shall exactly coincide with the 90th degree cut on it, as in the figure, and then raise the telescope to the 0° or zero of the quadrant, as indicated by the dotted lines, it will be at right-angles to the plumb-line, and will point as exactly in the direction of the horizon as if the horizon and not the plumb-line had been visible and employed for the purpose. If now we direct the telescope to P, the pole (supposed a visible point in the heavens), as in the figure, and note the degree on the quadrant to which, when so directed, it is opposite, say 50°, we shall know that that is our latitude, that is, as was before explained, the angular elevation or altitude of the pole above the horizon of the station of observation. I have stated the matter in the simplest possible form, divesting the problem of numerous minor considerations which have to be attended to in actual practice.

I have here supposed the plumb-line to be acted upon by gravity equally in all directions, and therefore to hang vertically, as in such normal circumstances it would do. But if the action of gravity should not be equal in all directions, it is evident that the plummet, being free to yield to any predominating attractive influence, would no longer hang vertically below its point of support. Now experience has shown that such equality of action does not always exist. High mountains in the vicinity of the station of observation have been found to disturb this equality, and very perceptibly to deflect the plumb-line from its true vertical direction in obedience to Newton's universal law of gravitation above enunciated. Let us see how this will affect the latitude.

In fig. 15 let AB be the true direction of the plumb-line, CD the true plane of the horizon, and P the north pole. Then the angle PBC, being the altitude of the pole above the horizon, will be the true latitude. Now suppose a mountain, M, to exist to the north of the station, its mass and vicinity will attract the plummet and cause it to assume the oblique direction EB, and the horizon will thus be made to appear in the position of the dotted line FG, instead of the true one CD, and the latitude or altitude of the pole will be PBF instead of PBC, which will be erroneous to the extent of the inclination of the incorrect and true horizons, *i. e.* the angle FBC. In this case the latitude will be ***diminished*** to that extent by the disturbing influence of the mountain attraction. If the mountain had been to the south, the latitude would have been ***increased***, and the reverse effects would occur in the southern hemisphere. As an actual example of such influences, I may mention that the latitude of Dehra, a town at the foot of the Himalaya mountains, was found to be erroneous, as determined astronomically, to the extent of nearly 38 seconds of arc, an error which, had that point been made the termination of an arc of meridian one degree in length, it would have made the earth's diameter about 82 miles too small: care, however, was taken to fix upon a termination for the Indian arc of meridian as remote from these stupendous mountains as circumstances would admit. But, even as it was, the point selected, though about 70

miles from the Himalayas, still proved, to a small extent, within the influence of their attraction.

Though mountains are the most obvious and most energetic agents in disturbing astronomical latitudes, other causes produce similar effects: masses of matter out of sight under the surface of the earth, if differing in specific gravity, being sufficient to introduce error by causing the deflection of the plumb-line.

There can never exist any guarantee that, in a given locality, some disturbing agency may not occur. The only way in which the natural difficulty can be overcome is, by making measurements in as many parts of the world and in circumstances as various as possible, in order that an error arising in one locality may be counteracted by a contrary error in some other quarter, and so a fair average be obtained. And this is one of the chief practical reasons for multiplying such measurements.

Fortunately the measurement of the angles of a triangle is not affected by these causes in any sensible degree whatever. Therefore triangulation marches ahead perfectly correct, so far as Nature is concerned,—she only interferes with the determination of latitude.

Now geodesy, besides affording a knowledge of the size and form of the earth, has been applied to another use by the French nation, namely, for establishing a *unit of linear measure*. It may be asked, What is a unit?—In this sense the word means a fundamental measure of length, as an inch, a foot, a yard, of such definite extent as to convey a perfectly precise idea of its length. But to say that a certain thing is a foot long does not convey any definite idea, because one foot may differ from another. If anybody will take the trouble to examine a number of ordinary foot rules, he will find among them very large differences, at all events, very perceptible differences. Therefore, to say *a foot*, means nothing in science, and different people have accordingly had different ways of fixing the idea of the foot or the yard. The English refer it to the pendulum. The connection between the pendulum and the foot is not at first sight very obvious; but, when we consider that the rapidity with which a pendulum swings is dependent solely upon its length, we then perceive how that rapidity may be used as an indication of length. A long pendulum oscillates more slowly than a short one, in a certain ratio well-known to mathematicians, which I need not dwell upon. Now the mathematician's conception of a pendulum is that of a body the whole of whose weight is concentrated in a single mathematical point, that body being suspended by a rod or string, totally without weight, and from a joint in which there is no friction, the whole being in a vacuum. I need not say that these are circumstances which cannot be commanded in actual practice; but if we know the size and the weight and form of the body of the pendulum, if we know the size and weight of the rod, if we make careful experiments upon friction, and if we know the amount of air that there is in the receptacle in which the whole moves; if we know these, we can reduce by calculation the results given by that pendulum to those which would be given by a perfectly mathematical pendulum. Such a pendulum will move with different velocities in different parts of the globe. The globe rotates on its axis. In doing so it generates what is called the centrifugal force—the tendency to throw

things away from it. That force acts in opposition to the central force of gravity, of which I spoke just now, which attracts everything to the earth. Now the attracting force we will assume, for our present purpose, to be constant, the same in all parts of the globe, but the centrifugal force must be greater at the equator than at the poles, and, as it is gravity which keeps the pendulum in action, this variation in its effect, caused by the centrifugal force, will compel the pendulum to move at different rates, according to the latitude of the station at which it is employed. We find that at the equator a certain pendulum will make 86,400 oscillations in one mean solar day. We find that in London the same pendulum will make 86,535 oscillations in the same time, the difference being 135 oscillations more in London than at the equator. At the pole it will make 86,640 oscillations, or 240 more than at the equator.

But to come to the matter in hand. In order to accelerate the equatorial pendulum and to compel it to keep pace with the polar pendulum, or the pendulum in London, we must shorten the equatorial pendulum. Most elaborate experiments and calculations have been made on the length of the pendulum, and the result is, that the mathematical pendulum—this imaginary perfect pendulum—oscillates exactly at the rate of one second per oscillation in London in a vacuum, if it is 39·13911 or $39\frac{1}{7}$ inches (nearly) in length. Hence we have in the pendulum an unchangeable means, afforded by Nature herself, of ascertaining a linear measure or unit. Provided we attend to all the conditions necessary to success, we can at any time go to Nature and ask her what the foot is, and she will reply to us truly.

It is a very awkward number, the number I have just given you; and I presume this has arisen from the arbitrary adoption of the foot before its scientific determination.

The national standard yard measures were destroyed in the burning of the Houses of Parliament, and new ones had to be made. Anybody who is interested in this subject should read the account of all the operations connected with the recovery of the national measure given by Mr. Bailey. It is one of the most interesting examples of experimental science that ever was published.

But the French were not satisfied with this means of obtaining a linear measure. They thought it too local; they thought it was not at all becoming in other nations to go to London to find out what their feet were, and that something more universal should be employed for this purpose. Accordingly, the National Convention in 1791 selected this method: They deduced from their geodesical operations the length of a quadrant of the meridian passing through the Observatory of Paris; that is to say, the distance from the equator to the pole on a meridian passing through the Observatory at Paris; and they took of this one ten-millionth part, and they called that a *mètre*. Now, we have seen a little of the difficulties of geodesical operations, and we have seen that such works are burthened with errors arising out of natural causes over which we have no control, such as irregular attraction. Therefore, this method of obtaining a constant length is one the efficacy of which many people doubt. Professor Airy, than whom there is no higher authority on such a subject, says in his Treatise on "The Figure of the Earth," that "the idea of replacing a

lost standard by an extensive geodesical measure is perfectly chimerical." The French and English, therefore, have distinct units; but the proportion they bear to another is well known, and therefore it is quite possible, though very inconvenient, to convert one into the other in any calculations that have to be made with the two.

Now, as to the value of all these works, quite apart from their interest,—as to their practical value to mankind, quite apart from the stimulus that they afford to his imagination, to his admiration of the works of nature—quite apart from those higher sentiments,—what is the value to man of such works? how do they affect his well-being? The answer is very simple indeed. Commerce is indispensable to man; navigation is necessary to commerce; navigation is dependent on astrouomy; and astronomy, as it is at present received, could not exist if there were no geodesical works. Having said that, I think it is quite clear that men owe something to geodesy.

The particular use that is made of geodesical measures in astronomy is this: they afford the basis of all astronomical distances. No astronomical distance can be determined without a previous knowledge of the size of the earth. I will illustrate this by a diagram in which the distance of the moon is determined. So slight an explanation as my time permits me to give can convey, of course, but a very imperfect idea of the delicacies required in such a proceeding; but still the main outline of the problem may be made tolerably clear in a few words. In fig. 16, the circle represents the earth, N the north pole, S the south. Imagine, for the sake of illustration, that it were possible to erect observatories at the north and south poles, and to keep men alive there to take observations. The earth is so infinitely distant from the stars, that a line drawn from the north pole to a given star and another line drawn from the south pole to the same star, will be sensibly parallel, owing solely to the immense distance of the star. The nearer the star might be, the more tendency there would be in those two lines to converge; but in reality, they do not sensibly converge, and they may be taken as strictly parallel. Therefore, you understand that the two dotted lines AN and A'S, if extended a sufficiently great distance, would touch the *same* star. Let M be the moon. Connect her with the earth by the lines MN, MS. You perceive that a triangle NMS is formed. How can we calculate the length of the side of that triangle from N. to the moon, or from S. to the moon? If we can do that, we shall know the distance. It is very simple. The astronomer at the north pole measures with an appropriate instrument the angle ANM contained between the star and the moon. He knows that the angle contained between the star and the axis of the earth is a right angle. He subtracts the measured angle ANM from the right angle ANS, and the result is one angle of the triangle, viz. MNS. The observer at the south pole measures also the angle A'SM, between the moon and the star. Here again he has a right angle contained between the axis of the earth and the line drawn from himself to the star. But the moon being below that line, he must add this observed angle to the right angle. He, then, has another angle of the triangle, viz. MSN. We know from our geodesical operations exactly the distance between the observers at the north and south poles, that is the polar diameter of the earth. Therefore, in the

triangle MNS, we have obtained from observation the angles MNS and MSN, and, the length of the side NS being known from geodesy, we have three elements of a triangle—one being a side, which, as I explained in my first lecture, suffices for the deduction of the other two sides, NM and SM, which represent the distance of the moon from the earth; a result, however, which we could not obtain without a knowledge of the earth's dimensions.

The sun's distance is determined by a process much more complex. There are several ways of doing it, but the most trustworthy method is by means of the transit of Venus. At certain periods the planet Venus gets exactly between the earth and the sun, and is seen to pass across the sun's disc as a small black spot. I shall not enter into this problem; it is totally impossible in the few minutes at my disposal to do so. It is explained in a course of lectures given by Professor Airy at Ipswich, in 1848, and he devotes nearly a whole lecture to it, and that an elementary lecture; and, after having explained it in his usual lucid manner, he states it as his opinion that it is the most difficult subject he knows of for a public lecturer. Without attempting a full explanation of this beautiful but complex problem, I may show you in what it consists. In fig. 17 the large circle represents the sun; NS the earth with our friends at the north and south poles as before; and V is Venus, between the sun and earth. Now, the gentleman at the south pole will see Venus projected as a black spot on the sun, in the direction SA; he will see Venus enter upon the sun's disc there, pass across it, and make its exit at B. Let us suppose that Venus leaves a visible line AB on the sun's disc along her path, as seen from S. The gentleman at the north pole sees Venus enter the sun's disc at C, and emerge from it at D, leaving, we will suppose, the visible line CD parallel to AB. Now, the width of those two lines apart will depend partly upon the *size of the earth*, and partly upon the distance of the sun from the earth. We can ascertain their distance apart by noting the time which it took the planet to describe the paths AB and BC respectively, the observers at S and N being very careful to record the exact times at which they saw the planet enter and leave the sun's disc. With these measures of time we can ascertain the distance apart of the two paths. I said that this distance will depend partly upon the distance of the sun from the earth and partly on the size of the earth. Of these two things we know one, that is, the size of the earth; we have, therefore, data for calculating the other, and that is all I can say at present about it. Here again, you see, that a knowledge of the dimensions of the earth is indispensable to the solution of the problem; and this knowledge geodesy alone can supply.

My audience, no doubt, are familiar with Cook's famous voyage to Otaheite. It was undertaken for the express purpose of assisting in the determination of this problem. It occurred in 1769. The next transit of Venus will happen on the 8th of December, 1864. It is predicted now, and, owing to the perfection of astronomical and geodesical science, it is as certain as that to-morrow is Saturday, that it will take place then.

Now, having the sun's distance, we can get something useful out of it. What is the sun's distance? It is just half the diameter of the orbit of the earth round the sun. Double this distance, and the result is the diameter of the earth's orbit. Having this distance, we have therefore

obtained for ourselves in the heavens a base line of enormous length. It is one hundred and ninety millions of miles long. I said a little while ago that two lines drawn from the two extremities of the earth's axis to a star would be parallel; but a line drawn from the extremities of the earth's orbit, which is so much wider, may not be quite parallel. It is found in reality that they are not. In some cases it has been just possible, and only just possible, with the finest instruments and with the greatest skill and labour, to ascertain that there is a small convergence of these two lines, by means of which astronomers have calculated the distance of certain fixed stars. They may be taken at twenty billions of miles, which is a quantity that one can mention, but not hope to realise. The distances of the planets are comparatively easy of discernment.

Hence, it appears that geodesy is one of the main foundations of astronomy. Having said that, I have said quite sufficient to assert its importance to man—its practical, utilitarian importance.

Now, there are other ways in which geodesy is useful which I have not dwelt upon. Geography is a science regarding which I need not say much to gain respect for it. It has always been cultivated in conjunction with geodesy. It has always been sought to unite these higher scientific results with results useful to geography. In India, accordingly, that object has been kept steadily in view, and, as I have worked in India, it is natural that I should refer to operations there.

The "Great Trigonometrical Survey of India" was commenced in the year 1799, by Colonel Lambton. He was then a young officer in Her Majesty's 33rd Foot, serving in India. He laid before Government a project for triangulating India. He was a man of great mathematical attainments, and the project was favourably received by the Government, chiefly in consequence of the advocacy of one whose name cannot be mentioned in this Institution without reverence—the late Duke of Wellington, who commanded the 33rd Foot at that time. His comprehensive genius enabled him to see the great value of such a work, and accordingly he gave it his strenuous support, and it was undertaken at his suggestion. There was associated with Lambton a gentleman named Kater, a name familiar to every scientific man in every civilised nation in the world. He subsequently left India, and pursued his scientific avocations in England. Under the auspices of these two famous men the survey of India was commenced. Colonel Lambton measured what we call the southern part of the Great Meridional Arc of India, from Cape Comorin to Beder. It is not my intention to enter into a criticism of that work. It was a most wonderful performance for the day in which it was executed. Colonel Lambton died at Hingun Ghaut, about fifty miles from Nagpore, in January, 1823, at the age of seventy. His fame is held in great respect by all who knew him, and by all who have studied his works.

Lambton was succeeded by our Chairman, Sir George Everest, who had surveyed under him. By that time science had made very considerable strides, and Sir George at once took advantage of all the improvements of the day. He totally re-organised the survey. He came home and had very superior theodolites constructed. So superior are they, that I believe the very theodolite he took out about thirty years ago to India is without an equal in the world at this moment. It was made by the celebrated Edward Troughton; and the graduation, the most important

part of the instrument, was executed by Troughton's own hand. I have worked with it myself most extensively, and I am happy to testify to its great merits in this place. He took out also a new base-line apparatus, that which I attempted to describe in my last lecture. This apparatus has not been superseded yet, but it may be one day. It was then the most perfect thing of the kind that was known. Sir George also took out two large astronomical instruments for the determination of latitude. He introduced improvements for which surveyors in India cannot be too grateful—luminous signals. I have not dwelt upon these details for I have not time to do so. But when I spoke of measuring triangles with a theodolite, it must be evident that I must have intended that there are conspicuous marks of some kind on the different stations by means of which the measurements could be made. Hitherto these marks had been poles or flags, and, in a climate like India, it was difficult to see them except in particular states of the weather. This involved great exposure, and during the rains, the best season for seeing opaque objects, great suffering. Sir George Everest introduced in India a peculiar instrument called the helistrope, a contrivance for directing to the observer the rays of the sun, which then looks like a star in daylight, and can be seen at immense distances. He also introduced a very powerful lamp, which could easily be seen by night. By these means the labours of the surveyors have been much lightened and the accuracy of the work greatly increased. He also introduced new methods of observing and computing, and established one consistent system throughout the department. It was a work of enormous labour, as at the time Colonel Everest entered upon these improvements he had not a single assistant who knew anything about the apparatus he was introducing. He had to train them all. New instruments are causes of intense anxiety to surveyors. They seem like human beings in the number of maladies to which they are subject, and the extremely complex and contradictory nature of many of their symptoms. No man can successfully pursue geodesy in distant parts unless he is something of an instrumental surgeon.

I have so little time left that I must pass over many subjects which I wished to touch upon. I should particularly desire to bear my testimony to the great necessity for system in surveying. I will illustrate it in this way. A workman has to make a chess-board containing sixty-four squares. Suppose he calls sixty-four workmen to him and orders each man to make a separate square. He tells them that the squares are to be one inch each way, and to be one-tenth of an inch thick. The men will all bring their squares. Will they fit? Most undoubtedly not, however skilful the workman may be. There will be an overlapping in one place, an hiatus in another, and so on. The conception formed by one mind of an inch and by another mind of the same measure will not be the same. The conception formed of a right angle by one mind and by another will not be the same. The thicknesses will also differ. The three elements will differ, and there will be a mass of confusion. But if a man makes all the squares himself according to rules which he has laid down for his own guidance, or if he employs machines, such as are constructed for making pins and needles and steel pens, repeating the same form with perfect accuracy any number of times,—if he employs a machine like that to make his squares with, then they will fit. Now, that is precisely

illlustrative of surveys. Everybody who has had anything to do with the compiling of maps knows that when he receives materials from a variety of sources he cannot make them fit. It is perfectly impossible. And each surveyor will contend that his work is perfect. Therefore, whose work to alter and how much to alter it, whose work to reject and throw into the fire, who can say? Hence a survey of any large tract of the earth's surface must, in order to give it any value at all, be executed upon one system. There must be one mind—I do not mean one mind throughout, but there must be the impress, as of one mind, upon the whole work. There must be the same linear unit, the same foot. There must be the same calculations, and the same method of using the instruments, or the results will clash.

Now the system carried on in India is, I may say, because I had nothing to do with organizing it, a very perfect system indeed. It is my humble opinion that anything which tends to dislocate that system, and to throw the various branches of the work into different hands, will be productive of results which all those interested in such matters will deeply deplore.

I have talked of geographical errors. I have said that men bringing different surveys together will find that their work will not agree always—never will, in fact. I may seem to be over refining. To show that I am not unduly refining, I will mention some errors that have actually been ascertained to exist in geography. Gassendi discovered the accepted length of the Mediterranean to be erroneous to an extent, not of a few inches, but of five hundred leagues. De Lisle shortened Asia by more than twenty-four degrees, a matter of 1,600 miles. The king of France complained bitterly that Casini's great triangulation had deprived him of a very large slice of his dominions. And one of the first discoveries that Lambton made in his survey of India was, that the peninsula in the latitude of Madras was forty miles in error. Now, that distance was determined by two astronomers, who independently ascertained the longitudes of two spots astronomically. They were able men and did their work faithfully, and it just shows what errors may be introduced by absolute astronomical determinations.

Sir George Everest was succeeded by Colonel, now Sir Andrew, Waugh, of the Bengal Engineers; and that officer carried out Sir George's system with ability and industry. He has resigned the service, and he is now succeeded by Major Walker of the Bombay Engineers, than whom a more able man could not have been selected.

Some of the fruits of the survey are these: upwards of 500,000 square miles triangulated rigorously. A meridional arc of 23 degrees, 1522 miles long, executed most accurately. A longitudinal, or arc of parallel, of $10\frac{1}{2}$ degrees, 670 miles long, completed and tested. Besides these, an atlas of India, on a scale of four miles to an inch, which is approaching completion, and which for extent and accuracy leaves nothing to be desired. Any gentleman particularly interested in the subject will see on the charts before me how the results of our survey are given at a glance.* They are well worth examination.

* These charts have engrossed upon them all the geodesical elements, viz. the length of the sides in miles and feet, the latitude, longitude, and height above mean sea level of every station, and the reciprocal azimuths of all stations. They are invaluable to the topographical surveyor.

I wish I had time to enter upon a description of the instruments before you, as perhaps they would interest many more than the dry details which I have given. I must, however, be very brief indeed. These instruments are all theodolites. Now, the object of a theodolite is to measure *horizontal* angles and *vertical angles* with accuracy. It consists of a telescope having freedom of motion in a vertical plane, and also having freedom of motion in a horizontal plane, provided with circles and with adjuncts thereto, which denote how much the telescope has moved in those two planes. That is the general principle of the theodolite. As it stands before you it has a very complex appearance, but the complexities are all secondary; it is an exceedingly simple instrument in its main features. It may be said to consist primarily of three master lines only. There is a line corresponding with the centre of horizontal motion, which we call the *vertical axis;* another line corresponding with the motion in the vertical plane, which we call the *horizontal, or transit axis.* Those two lines must be exactly at right angles to one another. The third line is what is called the *optical axis* of the telescope—the very centre of the telescope. That line must be exactly at right angles to the *horizontal axis;* and it must bear such a relation to the vertical circle that when the commencement of the circle is opposite to the pointer, when the circle reads 0°, then this *optical axis* shall be exactly horizontal. These are the three master lines of the theodolite. Everything else that you see are mere appliances to secure these ends, and to increase the convenience of using the instrument. This instrument has been lent to me very kindly by Messrs. Elliott Brothers; it is a fine instrument; it is constructed more for astronomical than geodesical purposes. In astronomy the determinations of the vertical circle are of more importance than horizontal determinations; therefore, the vertical circle is large compared with the size of the instrument. If it had been constructed for geodesical purposes, the horizontal circle would have been made much larger in proportion to the vertical. It is simply this that constitutes the difference between the theodolite and what is called the altitude and azimuth or altazimuth instrument, of which this is a specimen. This other instrument is very curious, and will bear close examination. It is made by a famous German artist, named Ertel. It has the same general arrangements as the former instrument, namely, horizontal motion and vertical motion. It is very peculiar in its construction. Amongst other things you will observe that the telescope is not over the centre of the instrument, as it was in the preceding case. Foreign observers and makers are fond of this construction, which is called the eccentric construction. It has its advantages. It does not necessitate quite so high an instrument as the other form. But there are reasons, too technical to be now discussed, which make me prefer the form usually adopted by English makers, in which the telescope is placed symmetrically over the centre of the instrument.

Here again we have an instrument made by Troughton and Simms, a 7-inch transit theodolite. It is a very good style of instrument indeed; it is useful both for astronomical and geodesical purposes. You perceive its general features are as like that first referred to, by Elliott, as can possibly be. Here is a theodolite which goes by the name of our Chairman, the "Everest theodolite." It was designed by him, and it has done more good work, I believe, than any instrument that was ever contrived

for the purpose. It is chiefly admirable for its compactness. Here is what is called the "Ordnance theodolite;" not quite with justice, I believe, for I have very great doubt whether the Ordnance are fond of that instrument—I hope not—I do not admire it myself. It is beautifully made, but the design is not such as I approve. We want, above all things, *stability* in such instruments. Stability is one of their chief essentials. The relative stability of instruments may be estimated by means of a triangle formed thus. Take the basis of the instrument, on which it stands, and consider that the base of the triangle. Take the centre of the telescope and call that the apex of the triangle. You have then a triangle of a certain form peculiar to that instrument. Fig. 18 represents the old pattern theodolite (which I am sorry to say is still more in vogue with English surveyors and engineers than it deserves to be); and the dotted lines show what the triangle for estimating its stability will be. Fig. 19 is the Everest theodolite, with its test triangle, also in dotted lines. These are drawings, on the same scale, of two instruments exactly equal in power and range. Compare them. In one the test triangle is *three and a half times* the height of its base; in the other it is *not once* that height. The old instrument has other defects in construction, on which I need not dwell; but the one I have mentioned is all-important.

I wish I could enter further into details, but it is impossible, as my hour draws to a close.

I have now only to vindicate the propriety of delivering these lectures in such an Institution as this. I think I need not say much for this purpose. The objects of Geodesy are, in the first place, of high scientific interest; in the second place, they seek to give us good maps, all the best maps in existence being founded on trigonometrical operations. No military man can doubt the use of good maps, and there can be no good maps of extensive parts of the universe without such works as we have been describing. Naval men attach even greater importance to maps, and well they may. The delineation of the coast line is a matter of life and death to them. But naval men owe more to us than even good maps. There is a book known to every seamen, called "The Nautical Almanac." Next to his Bible, I believe he loves no book so well; and he has great reason to esteem it, for without the help of such a book modern navigation would be out of the question. In that book is contained every astronomical prediction that can be made which is necessary for successful navigation. Now the predictions of that book, as I have endeavoured to show, being deduced in great measure from our knowledge of the distances of the heavenly bodies, could not have been made without the help of geodesical measures. I have, therefore, I think, established that, although every naval and military man need not be, in order to be a good officer, a geodesist, yet, in an Institution like this, which is organised on very enlightened principles, such a subject may possess some interest, and is entitled to consideration.

THE CHAIRMAN: I think I give expression to your wishes in returning our best thanks to Colonel Strange for his kindness in giving this lecture, and for the luminous manner in which he has explained this difficult subject.

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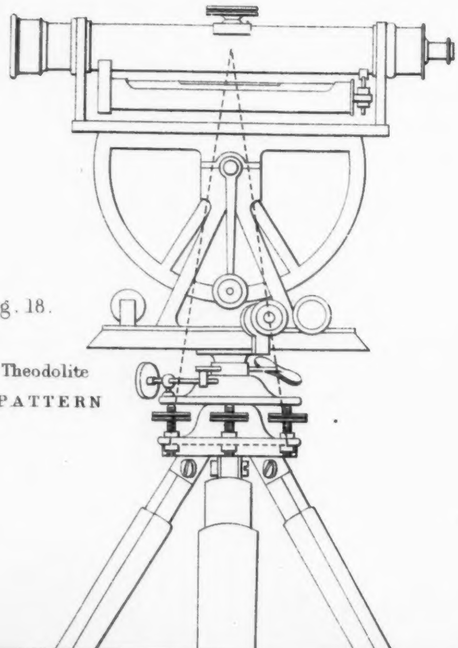


Fig. 18.

5 Inch Theodolite
OLD PATTERN

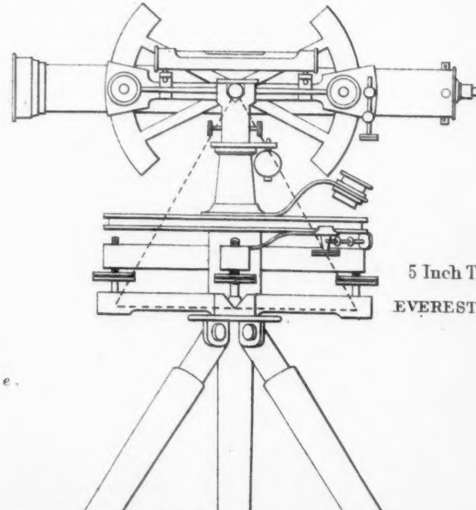


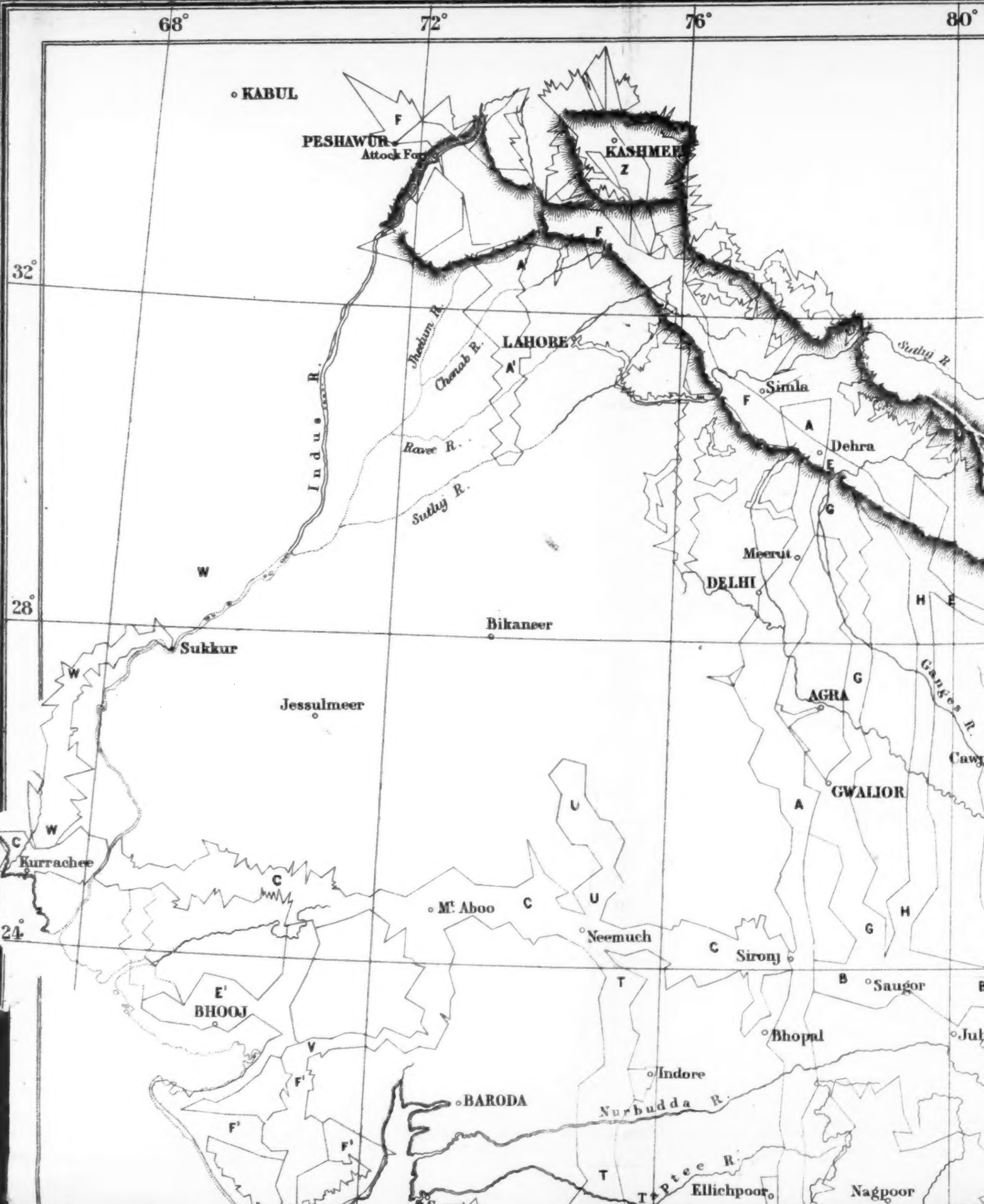
Fig. 19.

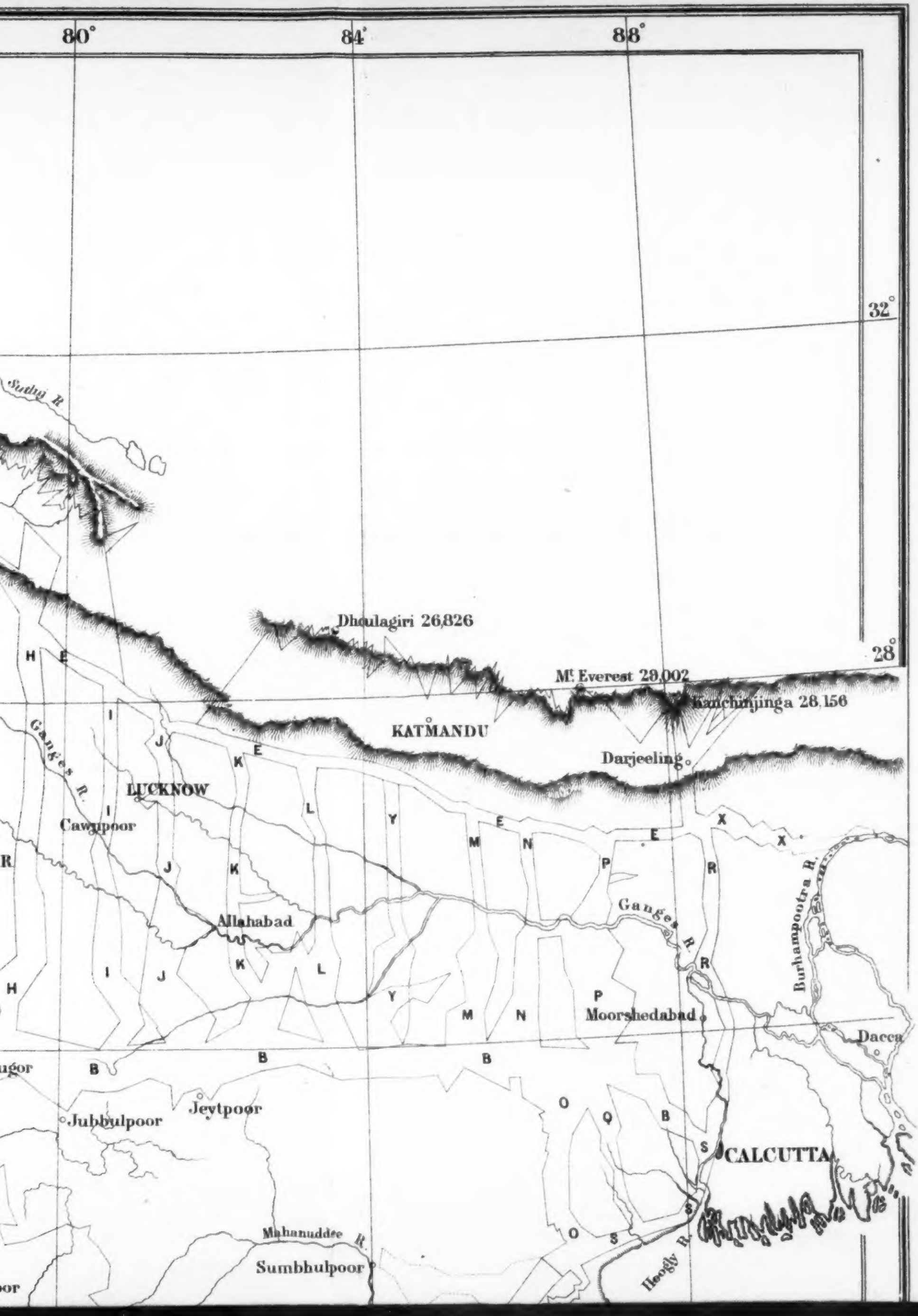
5 Inch Theodolite
EVEREST PATTERN.

Scale ¼ Size.

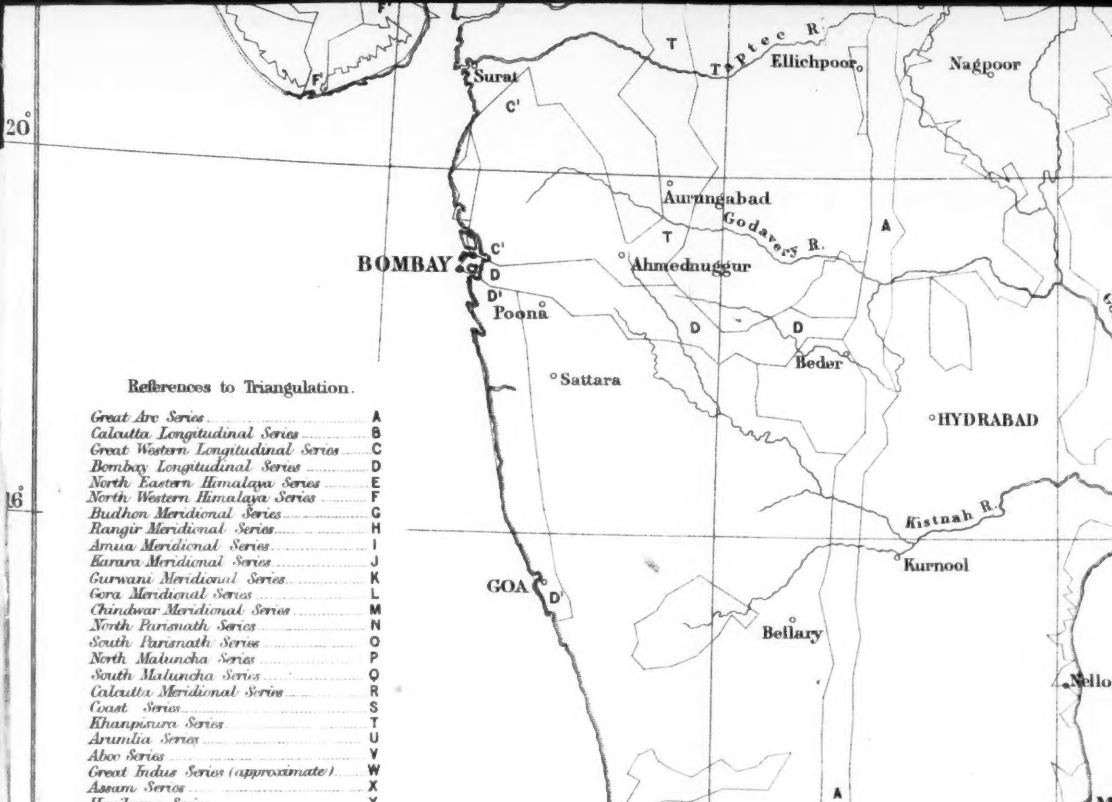
J.R. Jobbins

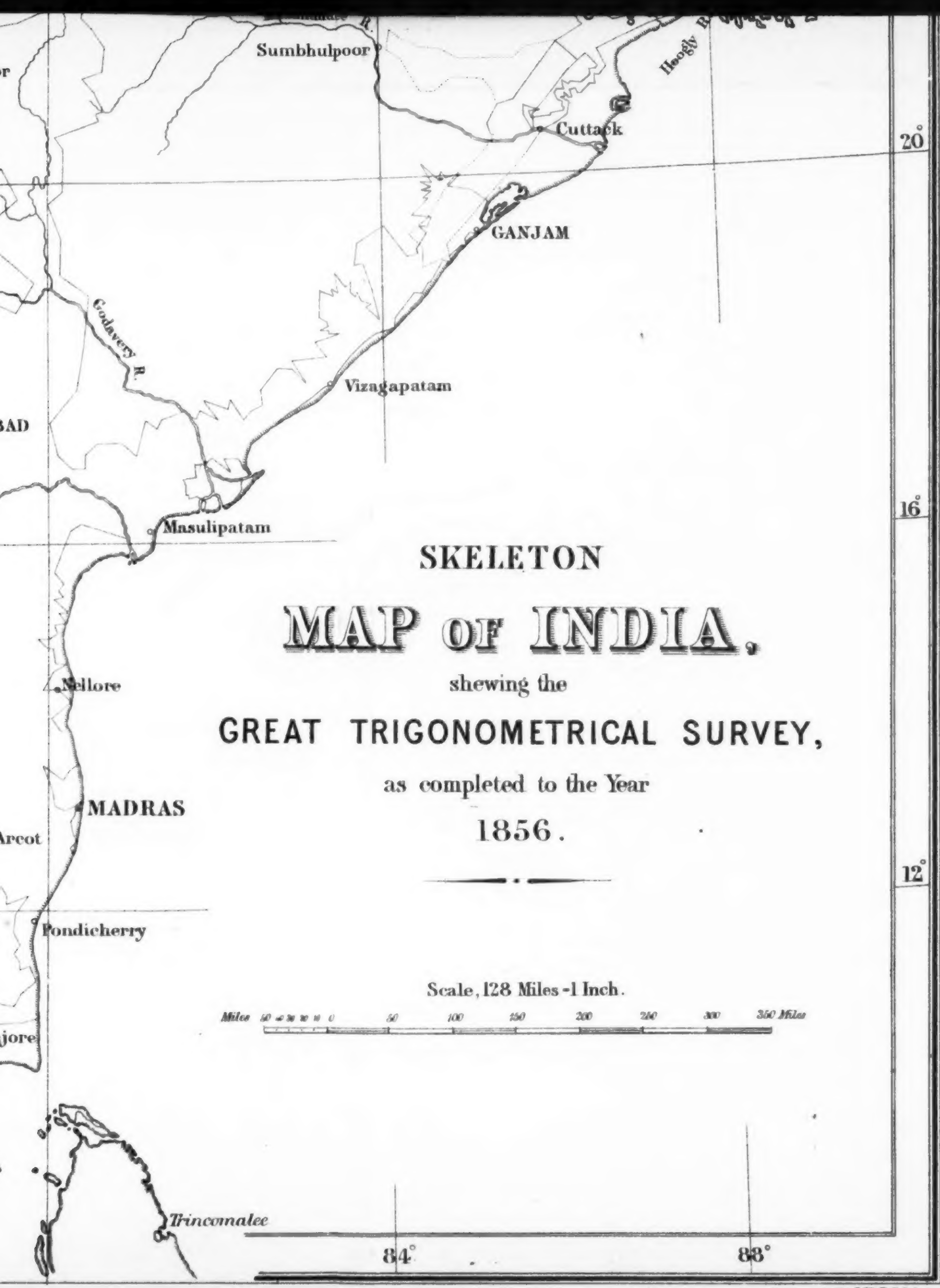
To face page 484.





80°
84°
88°
32°
28°
Sutlej R.
Dhaulagiri 26,826
Mt. Everest 29,002
Kanchinjinga 28,156
KATMANDU
Darjeeling
Ganges R.
LUCKNOW
Cawnpoor
Allahabad
Ganges R.
Burhampootra R.
Moorshedabad
Dacca
Jubbulpoor
Jeytpoor
CALCUTTA
Mahanuddee R.
Sumbhulpoor
Hoogly R.


References to Triangulation.
Great Arc Series A
Calcutta Longitudinal Series B
Great Western Longitudinal Series C
Bombay Longitudinal Series D
North Eastern Himalaya Series E
North Western Himalaya Series F
Budhon Meridional Series G
Rangir Meridional Series H
Amua Meridional Series I
Karara Meridional Series J
Gurwani Meridional Series K
Gora Meridional Series L
Chindwar Meridional Series M
North Parisnath Series N
South Parisnath Series O
North Maluncha Series P
South Maluncha Series Q
Calcutta Meridional Series R
Coast Series S
Khanpisura Series T
Arumlia Series U
Aboo Series V
Great Indus Series (approximate) W
Assam Series X
Hurilaong Series Y
Kashmir Meridional Series Z
Jogi Tila Meridional Series A'
Rahoon Meridional Series B'
North Konkan Series C'
South Konkan Series D'
Kutch Series E'
Kattiawar Triangulation F'
The zigzag lines denote the spaces actually triangulated.
Surat
Taptee R.
Ellichpoor
Nagpoor
20°
Aurungabad
Godavery R.
BOMBAY
Ahmednuggur
Poona
Beder
Sattara
HYDRABAD
16°
Kistnah R.
Kurnool
GOA
Bellary
Mangalore
Bangalore
Arcot
Seringapatam
Ootakamund
Trinchinopoly
Tanjore
Trivandrum
Cape Comorin
72°
76°


SKELETON
MAP OF INDIA,
shewing the
GREAT TRIGONOMETRICAL SURVEY,
as completed to the Year
1856.
Scale, 128 Miles = 1 Inch.
Miles 50 40 30 20 10 0 50 100 150 200 250 300 350 Miles
Sumbhulpoor
Cuttack
GANJAM
Godavery R.
Vizagapatam
Masulipatam
Nellore
MADRAS
Arcot
Pondicherry
Trincomalee
20°
16°
12°
84°
88°

J.R.Jobbins.

Friday, May 2nd, 1862.

Lt.-Col. LE COUTEUR, Coldstream Guards, Member of Council, in the Chair.

ON THE USE OF CYLINDERS IN LAYING SUBMARINE TELEGRAPHIC CABLES.

By Captain J. H. Selwyn, R.N.

It so happens that no longer ago than yesterday an article was written to "The Times" on a question which is still occupying public attention, viz., that of the Atlantic Telegraph Cable, although for the moment its accomplishment seems to be rendered more difficult by the unfortunate circumstances which have plunged the American States into the horrors of civil discord.

It will be easily conceded that novelties of structure are then most useful, and are therefore generally most required, when novel operations have to be entered upon.

No enterprise of this age has greater claims to novelty than that which has sought, which still seeks, to establish telegraphic communication, by a submarine cable, between the Old World and the New.

I claim, without fear of contradiction, the solution of the problem, as far as the laying of such a cable is concerned, as the birthright of the seaman; and I am now here to ask the attention, and attempt to merit the approval, of my brother seamen while I propose what I must acknowledge is a novel, and I hope they will think is a seamanlike means of performing the difficult task which I have just claimed for our profession.

Neither seamen nor fishermen will have much hesitation in granting that the best of all ways of getting a long line laid out free and clear is to run it off a reel, and our invariable practice at sea in such cases is to use reels whenever they are possible. Thus, when the question was first mooted of laying a cable, comparatively a mere thread, across the Atlantic, it is no wonder that Brunel (on being appealed to for his opinion) should have advised the use of a reel. But how to carry such a reel as would be necessary? This was held to be a fatal objection at the time, but I am now, I hope, about to show how it may be overcome. Your reel may be made in the form of a cask or cylinder, and then it will "carry itself," float, *i. e.*, with the cable reeled upon it. It will have paddle-wheels on the ends, and be set in a frame by which it may be

towed, revolving as it passes through the water. The model cylinder which you see on the two lines stretched across the platform overhead represents the form I propose. I am sorry there is here no water sufficient to float it, for seamen are generally supposed to be at their wits' end in the absence of that element; but yet, as we ought to be always ready to take a lesson from any one, I have thought I might here take a lesson from Mons. Blondin, and substitute a tightrope for the sea.* It is almost as dangerous, and therefore may in some other respects be likened to it, and it happens to answer the purpose in showing the unrolling and consequent descent of the cable moderately well.

I grant that this will have to be a big cask, but perhaps not so big or so unwieldly as would at first sight appear probable. First, what is the weight and size of the cable to be carried? I will take the late Atlantic Cable as a specimen. This weighed, in air, 1 ton per mile; in water, 14 cwt. Its diameter was $\frac{5}{8}$ths of an inch. Suppose we have to carry 1,500 miles of such a cable, and in round numbers we will say it weighs 1,500 tons (neglecting the sp. gr.). I cannot tow my reel conveniently, as I should wish, if it is more than about $\frac{4}{10}$ths immersed, so I want more than double 1,500 tons as the carrying power of the cask, cylinder, or reel. I find by calculation that a cylinder 60 feet long by 50 feet in diameter will have a tonnage of 3,386. Four-tenths of this is 1,354 tons, leaving 146 tons to make up the 1,500, which must be accounted for (if I do not desire to increase the size of the cylinder) by the different specific gravity of that portion of the cable which is immersed. This will easily be done if we consider that the gain from this cause will be equal to 406 tons, or there will be a diminution of the weight to that amount of the $\frac{4}{10}$ths of the cable which will be immersed. The diagram No. 1 shows the proportion which a cylinder bears to the ship towing it. The cylinder shown there is calculated to carry a cable which has less specific gravity, and less weight, but which is one now generally approved of, and which I have little doubt must eventually be used. It is designed and constructed by Mr. Allan, and specimens of it are upon the table. That cylinder,

No. 1.

A.—Ship 300 feet long, 50 feet beam. B.—Cylinder 50 long, 30 diameter.

therefore, has a diameter of 38 feet only, by a length of 50, which gives a tonnage of 1,628, and is fitted to carry a cable whose weight in air is 10 cwt., in water 4 cwt., and diameter $\frac{1}{2}$ inch—length now thought sufficient 1,000 miles. This for two cylinders will be 2,000 miles. The distance is 1,650 nautical miles, and this will therefore give a slack

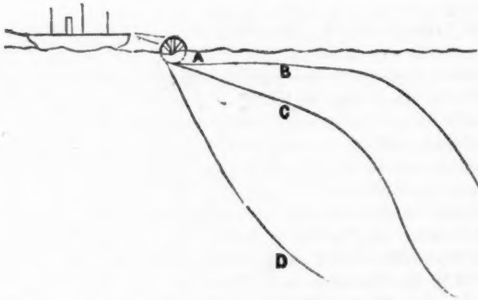
* Two lines were tightly strained across from gallery to gallery, and on these the cylinder revolved as it was drawn along, and paid off the cable below. J. H. S.

amounting to 20 per cent., which is ample. Now, as to the space occupied by the cable when reeled on. I find (referring still to the old Atlantic) that for 1,500 miles of it, $\frac{5}{8}$ths in thickness, on a cylinder whose diameter is 50 feet and length 60, there will be in the 60 feet 1,153 turns, making one fake or layer of $31\frac{8}{10}$ miles, and that of these layers there will be 48, making a total thickness of two feet six inches only.

In no other way can you stow it as neatly or in so small a space, and you can reel it on evenly and quickly by mooring the cylinder off a wharf, and either have steam-engines on the wharf to set the cylinder in rotation or use your paddle-wheels, which, as shewn in the model, are attached to the ends to do the work. As the tide or stream passed the cylinder, it is evident that it would operate on the paddle-boards and cause rotation. The principal object of the paddles is, however, not this. You will observe that they do not move independently of the cylinder, that they are, in fact, fixed to the cylinder, and its axles, as I have explained; therefore, if subjected to the action of a current of water, they would cause the rotation of the cylinder. But what will be their action while the cylinder is being towed forward by the ship? What would be the result if they were not present? The end of the cable being once let go, or allowed to sink, the whole cable would run off unchecked, and deposit itself in a coil on the bottom. But the paddles will prevent this by beating the water and causing forward movement of the whole body. It appears then that the weight of cable is as a constant clock-weight—taking the place of steam in producing motive power—and capable of relieving the ship towing, under certain circumstances, of a portion of the work. But this action, whatever its amount, is co-existent with another. Whether, in a current, the water passes by, and impinges upon, the paddles; or whether, as in towing, the body to which the paddles are attached passes through the water, the result is the same, namely, the rotation of that body. So, as the cylinder is towed forward, the cable is thrown off, with an acceleration due to the weight of the cable, and a retardation due to the diminishing diameter of the reel, as compared with that of the paddles. There is also another compensation. As the cable is thrown off the cylinder lightens, and less resistance will be opposed by the paddles to the dragging off of the cable. But coincidently, the depth of water, and therefore the weight suspended, will have diminished, and therefore the diminution of resistance is only what would have been required. The motive-power which I have spoken of as being derived from the weight of cable supended, was remarked upon immediately by a friend whose opinion I early sought on the subject, Mr. Gravatt, F.R.S., a mathematician whose name need only be mentioned to ensure respect for his dicta on such a point. Hs said as soon as he saw the model,—"Why, it will run over the ship." It was true enough, if the ship had not had steam-power sufficient to get out of the way, but on going more into the matter, we found that this would be the action. If you could only go as fast as the cable could sink, *i. e.* about two miles per hour, then the weight of cable would assist the towing. If you went faster than this, then, owing to the angle at which the cable descended being altered, growing more astern, it would not help the cylinder forward at all at a high speed,

and less as the angle with the horizon decreased. After the angle of 45° is passed (see diagram No. 2) the backward pull exceeds the forward impulse, and *vice versâ.*

No. 2.



A—Curves of cable when ship goes faster than cable can sink. A B increases in length if specific gravity is diminished or speed of ship increased.
C—Curve when cylinder is stopped on its way.
D—Catenary curve assumed when progress has been stopped long enough to allow cable to reach it.

Thus, I neither mean to propose to you that the cylinder should lay its own cable, nor do I fear that it should run over the ship, although these forces will be acting in the way I have described at certain times and under certain circumstances.

It is clear that, having no cable to carry in the towing-vessel, you can carry plenty of coals, and that the trim will not be subject to the tremendous variation between 1500 tons and nothing by way of cargo, independently of the coal consumption.

Here, then, is a reel which carries your cable in water, keeping it cool, which you cannot sink in a gale (for where ships founder casks often float), which does away with all danger to ship and crew, and which I think you will admit, in any moderate weather, would lay your cable as straight and free from kinks as possible.

I have not yet told you, what is nevertheless a very important point, that the weight of this cylinder would be about 260 tons, if of half-inch iron plate, inclusive of two double ends, two partitions, paddle-wheels, stays, frame, &c. &c., and that the total cost would be about £4,000, one-sixth of the value of a ship, if built to carry the same quantity of a similar cable.

The electrical communication which it is necessary or at any rate advisable to keep up during the towing of the cylinder and deposition of the cable is provided for by passing the inner end, in coiling the cable on, out through a pipe leading from the surface of the cylinder to the axle. Here it is allowed to revolve freely, dipping into a cup of mercury on the frame, or otherwise spring contact may be employed, and from this point

a short cable or gutta-percha covered wire is led along the towing-cable to the ship.

If we consider farther the action of the cylinder when towed, we shall see that, whether the cable is allowed to run off or not, the paddles will cause the cylinder to revolve directly, and in proportion as the ship towing moves ahead. There would be, I have no doubt, a considerable diminution of speed consequent on the towing so large a body while going out to the mid-Atlantic, and therefore not giving off cable. But it need scarcely be feared that the speed of such a vessel as the Terrible, which is, perhaps, the best adapted for the purpose, would be diminished to anything like half her usual rate, which is ten knots. Therefore I believe she would be able to go seven with this reel astern. A proposition has been made by some naval officers that I should add to the cylinder a false bow of iron, which might be knocked away after getting out to mid-ocean; but I am opposed to this suggestion for two reasons: First, because all unnecessary complexity is to be avoided, the most perfect machine being always the most simple that will fulfil the purpose; and, secondly, because if better water-lines and easier towing be absolutely required, the best way to get it in this instance is by increasing the size of the cylinder, and thereby making it float lighter from the beginning. However, my own impression is decidedly, that if we can do it well enough, we shall do it quickly enough. *Sat cito si sat bene* must be our motto, and if we can accomplish seven knots, or 168 miles a-day, it will, after all, only take five days to reach the mid-Atlantic, the nautical distance being half of 1650, or 825 miles only. In support of my belief that this speed would be attainable, I may mention that the Tartarus, of about 150 horse-power, towed the Caledonia three-decker at five knots, her own speed being eight, that the Napoleon towed two French line-of-battle ships with a diminution of only two knots of her usual speed; and lastly, that the friction, which it is known offers no inconsiderable part of the resistance to the passage of bodies through water, is here, to a very great extent, absent, owing to the revolution of the cylinder on its axis. Whatever may be, however, the force of the objection to be made as to the towing, it cannot equally apply during the process of laying cable. Then, not only will the cable aid the advance of the cylinder under certain circumstances, which I have already pointed out, but with every mile traversed the cylinder throws off a portion of the weight, rises out of the water, and offers a better shaped bottom for passing through the fluid. But I should deserve the name of a fair-weather seaman if I failed to notice the probable action of a gale, or a heavy sea, on this system of laying. Let us suppose, then, first, that a gale is encountered before beginning the laying, while each ship is towing her cylinder to the mid-Atlantic, or elsewhere. As for the cylinder itself, it is absolutely safe under such circumstances, as also the cable upon it, unless the ship, by lubberly management (which I can scarcely suppose to be likely), runs into it, then some damage might occur, either to the cable or the frame by which the cylinder is towed. I do not say it would be inevitable that such damage should occur, for I think that in many cases of contact between the ship and cylinder it would be pushed away without more injury than denting the frame which surrounds it, and which would be

made of hollow beams, constructed from half-inch plate iron. But this cause of danger, if it exist, is equally to be found in the system of laying from ships; indeed, such a case has already occurred in laying the Toulon and Algiers cable, where, on one occasion, the operation was suddenly stopped by a French steamer, charged to convoy her, running into the vessel carrying the cable. I will, once for all, remark that if, of two systems, the one can be shown to be safer, more expeditious, and less expensive than another, it cannot fairly be required that there should be no difficulties whatever in it, while that other is full of them. Laying cables across the ocean, whatever may be affirmed by landsmen, can never be other than a most delicate and difficult operation, requiring most scientific seamanship, calling into action all the practical resources of the sailor, combined with whatever aids science can supply.

But to return to the case of a gale occurring. You would lie to, run before it, or keep bow to sea under short steam, just as circumstances might require. If necessary, you might even let go the cylinder, taking care to adopt such precautions as not to lose sight of it, and again make fast when the weather moderated. My own opinion, however, is, that under no conceivable circumstances could such a course become necessary.

The second difficulty which may occur is, a gale during the laying. This may declare itself ahead, astern, or on either beam. If the gale be ahead a diminished rate of progression will be the result, for, if the captain knows his work, he will not attempt a high speed. "Thrashing at it" would do no good, and might do a great deal of harm. But at any rate not so much danger need be apprehended as with a ship which has the cable coiled in her hold, for several reasons. First the pitching and rolling, as you will see by the plate, are, as well as the scend, either totally absent in the cylinder or very materially modified; the rise and fall of the wave, together with its forward impulse during the short time it is passing under the cylinder, being the measure of motion imparted to the cable, which is always being steadily unrolled or paid out. There is no uncoiling in a hold or handing out packings or lashings (see Blue Book), nor any landsman superintending a brake (break?) while he himself is scarce able to stand or see, and very likely devotes one hand to his own purposes and one to the requirements of the cable, if even he is able to do that. About the orthography of this word brake (break) there is a great difference of opinion, some spelling it one way, some the other, but I am inclined to think there is great similarity in their action as applied to this purpose, for the *brake* generally breaks the cable. The most perfect brakes which I can find are the paddle wheels, for these, according to the proportion which their diameters bear to the diameter of the cylinder, will either throw off slack or apply a per-centage of strain as may be desired, the necessary alteration being accomplished by the use of very simple mechanical appliances which I will presently describe; and more, they will resist the *dragging* off of cable, never absolutely, but as the squares of the velocity with which it is sought to be done, so that any strain due to the rise and fall of a wave will be given way to; but the pulling off of cable in excess of the rate at which the ship is going through the water will be effectually resisted.

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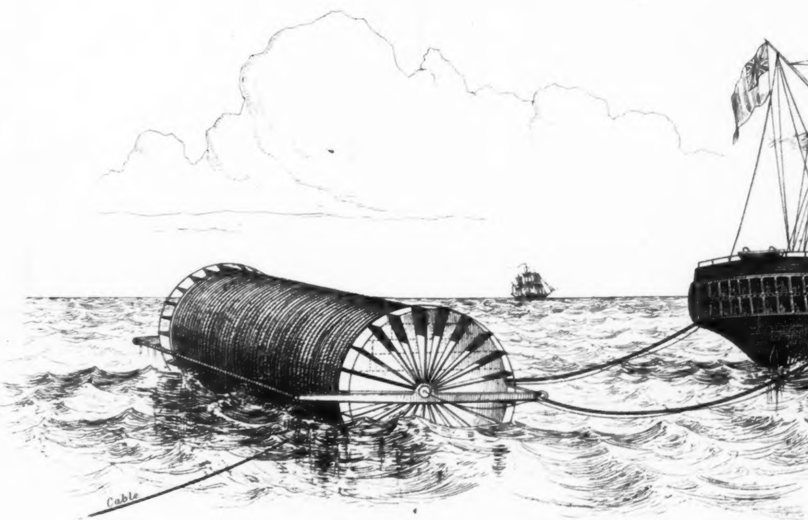
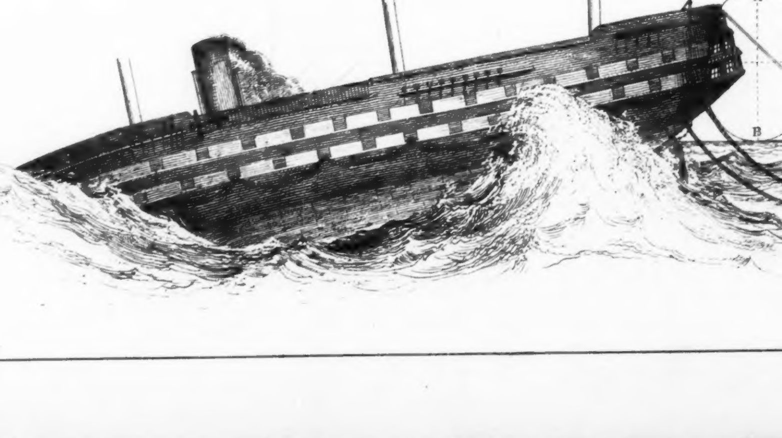
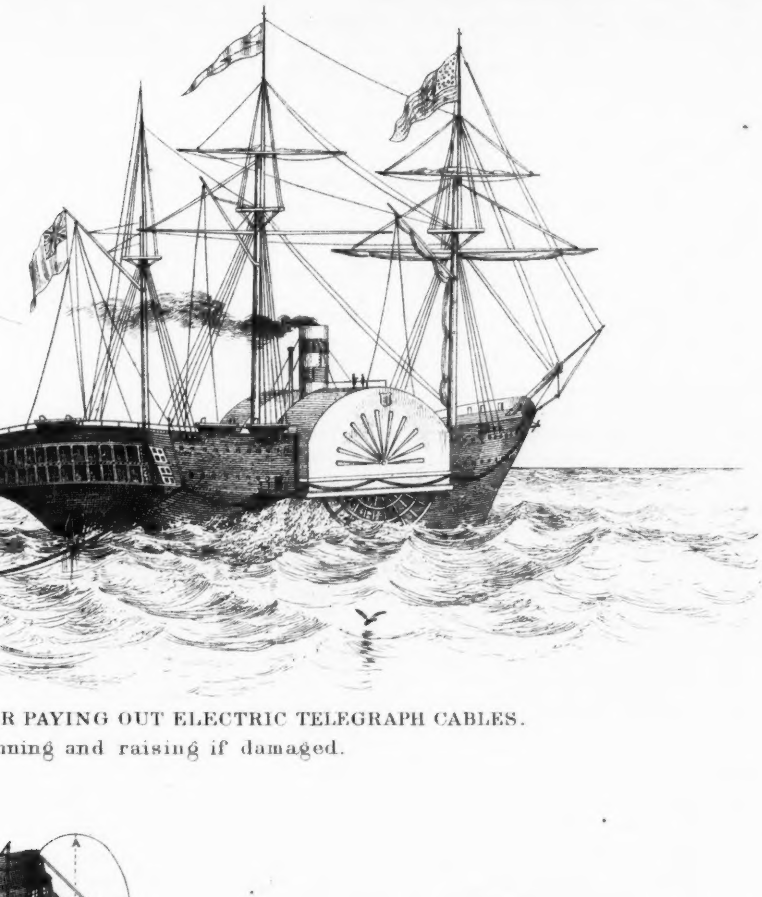


CAPT. SELWYNS (R.N.) APPARATUS FOR PAYINC
Or for under-running and





R PAYING OUT ELECTRIC TELEGRAPH CABLES.

nning and raising if damaged.

J R Jobbins

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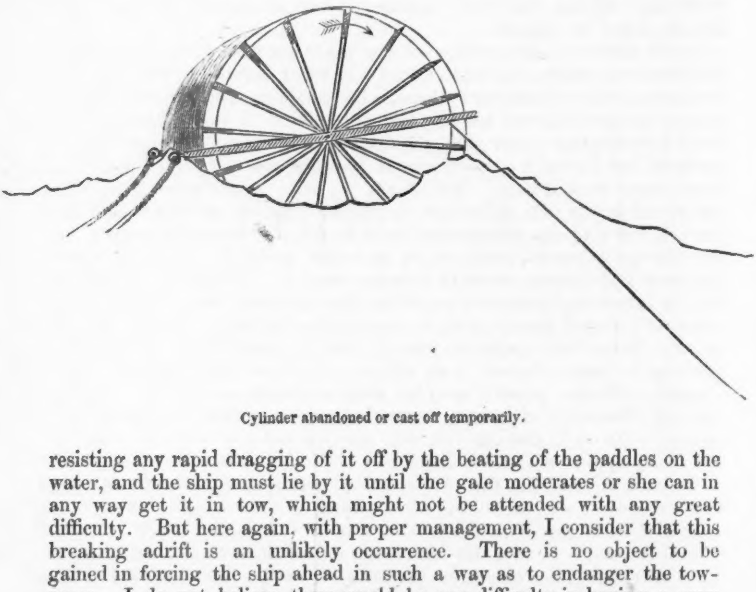
The appliance above referred to, and which is shown in the patent drawings,* consists of a clutch fixed on the fore part of the frame on each side at the spot where the centres of the paddle-floats pass during the revolution of the wheels. This is moveable on its axis by pulling ropes from the ship. If the one end be projected forward it will encounter the arms, which, like spokes of a wheel or capstan bars, are fixed on the heads of long screw radii, and these when moved cause the recession of the paddle floats to their common centre. If the other arm of the clutch, on the contrary, be the one projected, then the screws are turned in the opposite direction, and the floats, instead of being "reefed," are "expanded." But this apparatus has been contrived more in deference to the views of others than my own conviction. I do not anticipate, though it would undoubtedly fulfil its purpose, any necessity for its use while laying cable. To return to our gale and its difficulties. If the wind be astern, I do not know any limit to the speed with which the cable may safely be thrown off in the path of the vessel as it certainly will be by the revolution of the cylinder. If the gale be abeam, a current course will be shaped, or rather the leeway must be allowed for as usual, and no fear need be entertained that the cylinder will not "come after the ship" perfectly square, for we are not towing as ordinarily by the apex of a triangle represented thus. The base is the stern of the ship towing, the tow-ropes forming the sides, and the hawse-holes of the ship towed the apex, but in a totally different manner, the points at which the tow-ropes are attached to the cylinder being more widely separated than those which they leave at the stern of the towing vessel. In towing a ship, as described above, if there be a heavy sea, she inevitably sheers about, even when well steered, and from that cause, as also the heavy pitching, brings great strains on the tow-ropes if she do not even break them. The heavy pitching is caused by the fact, illustrated in the plate, that the wave continues to raise the stern until it reaches the centre of the ship's length, causing thereby a motion in a vertical direction much exceeding the height of the wave alone, in fact one due to a multiple of that height by the half length of the ship.

I may here mention that I propose to use as towing cables Manilla hemp combined with steel wire, which experience has shown to be the best means of obtaining great strength and great lightness. Four of these would be used, two of which as preventers; I should prefer to shackle them to chain cables on board the towing vessel, passing them out of the hawse holes, and hanging them outside the ship with proper stoppers and quarter tackles. Also at the points of strain on the cylinder and the ship I would make use of "buffer" or spiral springs to diminish any jerking action. Counters for the number of revolutions by bell signal to the ship, lights for night work, means of locking the cylinder, and either stopping or retarding its revolution, or causing it to revolve by hand, would also probably be adopted. I think most of the ordinary difficulties which can be foreseen have now been considered, but, if a breakdown of engines or other extraordinary difficulty should occur, it may be asked how we should then act? The engine stops. If you have, as you probably would have,

* The number of the Patent is 2,884.

a consort, you may, without much danger or difficulty, change places with her. There is no shifting possible if the cable is coiled on board a ship. She may, it is true, be taken in tow, but I have already shown why it is much more difficult to tow a ship than this cylinder, not as regards the rate, but the breakage of tow-ropes. But if the tow-ropes should, with the cylinder, be unfortunately carried away in fine weather, you would of course soon make fast again, while in a gale the cable will take about two hours, or perhaps more, before the curve, which I shall presently show to exist during the laying, will have sunk sufficiently to allow of a fair strain being brought upon it. Then the cylinder will of itself turn round and ride to the cable, giving off cable slowly in answer to any strain, but



Cylinder abandoned or cast off temporarily.

resisting any rapid dragging of it off by the beating of the paddles on the water, and the ship must lie by it until the gale moderates or she can in any way get it in tow, which might not be attended with any great difficulty. But here again, with proper management, I consider that this breaking adrift is an unlikely occurrence. There is no object to be gained in forcing the ship ahead in such a way as to endanger the tow-ropes. I do not believe there would be any difficulty in having a crew of ten men or so on the cylinder frame during the whole operation if it turned out to be desirable, and would cheerfully volunteer to take charge of them myself. I know that a ship in a gale of wind may founder, particularly if she has or has had telegraphic cable coiled in her holds and on her decks, and is either, therefore, over weighed or not ballasted, while I am satisfied that this structure would be almost if not quite unsinkable by anything in the shape of wind or sea. If it should even leak, which is little to be feared in such a vessel, cask, or cylinder, proved as it might be by hydrostatic pressure, then it may be made to pump itself out by very simple means whenever it is revolving, as is done every day in our sugar refineries and other works where large cylinders heated internally by

steam have hollow axles with scoops attached inside as radii. These take up the condensed water from the bottom as they pass through it and deliver it at the axle.

If it be desired to lift cable which has already been laid, this may be done by making fast to the after-part of the cylinder frame, and towing in the reverse direction. The paddles will, as before, cause revolution, and wind up the cable. Under-running may also be accomplished in the same way by taking two or three turns of the cable round the cylinder, and towing or slowly moving the cylinder in the direction which you wish to raise. For these processes, in any moderate depth of water, say three or four hundred fathoms, the cylinder would be most valuable, while even in greater depths it might sometimes be successful where any other means would fail. In fact, any cable which would bear its own weight might be thus recovered or repaired.

As the cable is by this system not exposed to any mechanical violence, as it is always in water, and may be tested in water during the whole of the reeling on, and on the outward voyage, it becomes almost certain that a mere gutta percha covered wire *could* be laid successfully. I have recommended, and I continue to advocate, the employment of internal steel wire, to give strength, but I should not consider it indispensable for laying alone if these means be employed. Yet I am no admirer of excessively light cables, which it is now the fashion to praise. Surface currents cannot be ignored, and they are greatly more to be feared, as the specific gravity of the cable is decreased, while, as we may wish to lift the cable, or some portion of it, for repair, strength is by no means to be neglected. To place steel or iron wire outside a cable, where the salt water can get at it, after whatever lapse of time, is only to insure its destruction by chlorides or oxides. It has been sought to remedy this by means which I can only compare to those adopted by an elderly lady of my acquaintance. She bought a Turkey carpet: in order that it might not be too roughly visited by the winds of heaven, or the feet of the profane, she covered it carefully with an Indian mat; but this also was too good to be ill-used, so she finally applied a brown holland over both. So it is with a telegraph cable, we first construct the two essential parts,—the conductor and its insulator—then we set to work to combat a shadow; we ignore the reduced specific gravity and treat the wire as if it alone were to be suspended in water. Under this impression we construct an outer system of wires enveloping the cable as in the arms of death. These again we are now covering with an insulating material, and it is probable that we shall perceive that the latter will also require to be protected by something else. Unfortunately in this case the brown holland is likely to be more expensive than the Turkey carpet. One electrician, whose cables are very beautiful to look at, has really put a larger copper conductor, in the shape of sheathing, outside his cable than there is inside it, and I strongly advise him to put an insulator outside that again, if he does not desire to throw away the copper or brass outside altogether. It cannot contribute to strength, for if copper could support its own weight in water it would be as well done by the small conductor inside. It professes, I know, to save the insulator from ill-treatment by cable layers or munching by molluscs, but is ill-treatment necessary, and will molluscs, where they do exist, be

more injurious to gutta percha than salt water to copper? As for *spiral* iron or steel wires outside a soft core and a straight conductor, I can find no words sufficiently strong to express my astonishment, at such a transgression of all mechanical laws, at such a self-evident fallacy. They are unprotected from rust or metallic veins on the bottom; they compress the soft core, and at the same time elongate and bring all the strain on the copper wire which they ought to sustain. They are liable to kink, and certain to decay. They present, in short, the best possible contrivance of "how not to do it." I have been told that the iron wires always broke first in the experiments, but I am sure that, had the test been applied of hanging a weight down a well by one of such cables, we should have had a very great tendency to untwist on the part of the spiral and a corresponding elongation of the copper wire. Of course the iron would, even then, break before the copper, but you would indefinitely attenuate the conductor, which, I presume, would not be considered desirable.

But with cables I have little to do. Whatever they may be, I will undertake to lay them (D. V.) in the same state in which they left the manufacturer's hands; and more no telegraphist can expect from seamen.

I would by no means be understood to say that a cylinder should be built, and sent at once to the work of laying an Atlantic cable, without trial. There can be no reason why full and satisfactory experiments should not be made previously; but if, as I hope, the opinions of many able men whom I have consulted already, as well in the naval as in other professions, and who are nearly unanimous in their belief in the feasibility of the plan—if these opinions are still farther confirmed by the verdict of this Institution; then surely it is worth while, by the expenditure of a few thousands, to try whether a stop may not be put to those failures which have already swallowed up a million and a half sterling, and so shaken public faith in telegraphic submarine communication that no proposition which involves a recurrence to the old method of coiling in ships will ever be listened to with favour by the Government or the nation. I mentioned the expenditure, but I am prepared to show that other uses could be profitably found for such a vessel as I propose, even if it did not fulfil the sanguine expectation which my friends and I entertain of success in laying cables by its means; for the necessity of storing submarine cables after manufacture in water has led, in some instances, to the construction of tanks on purpose. Even there, the water has to be changed and, if possible, kept cool by pumping. But such a cylinder as this would, if left moored in a tideway, keep rotating, and the cable would be perfectly safe on it, whether as regards mechanical violence or raised temperature. If, in spite of every care, the testing should show a fault while laying, supposing the faulty part to have been paid-out, it would be possible to reel it up again, either by towing in the opposite direction, or by a hand-motion given to the cylinder from the frame. If the fault were discovered while still on the cylinder, as there are about thirty-one miles in each layer, the operation of laying may be stopped, and the fault be cut out whenever necessary. But faults can scarcely be expected to occur, when a cable is treated as it would be on this principle. They are more likely to exist, or be caused, where the cable, in a hold and during its coiling into it, has to be subjected to a handling which, even where every care is taken,

is too likely to be attended with accident, and which gives opportunities for wilful damage, and which have not always been passed over without harm. Here, on the contrary, nothing but water ever touches the cable after or during the coiling-on—the very coiling is, to speak correctly, now changed to a winding or reeling on, which is far less likely to injure the cable, and the difference of which any seaman will readily understand. A similar motion in unwinding or paying-out will do away with all necessity for brakes, and most of the causes of breakage.

I have now, I venture to hope, sufficiently explained a system of laying and generally treating submarine telegraph cables, which at least cannot be said to be objectionably complex; and I hope that a free discussion of its demerits or otherwise may bring out all those "No's" which are much more valuable to every inventor than any number of "Yes's."

Here, as at the Naval Architects' Institution, where I have recently been kindly permitted to read a paper on the same subject, I am fully conscious of the great competency of my hearers to judge the merits of the system; and, therefore, whilst thanking the members of the Royal United Service Institution most warmly for their goodness in allowing me thus to bring the matter before them, I have only to beg for an impartial consideration of the subject, and that I may have the opportunity of answering, if that be possible, any objections which may suggest themselves now or hereafter.

One word more and I have done. There may be objections to be made, and minor difficulties to be overcome in this as in every other novelty; but there is nothing that a seaman need fear.

On the other hand, I fearlessly maintain that, unless by a miracle, no cable could ever be successfully laid over such a stretch as the Atlantic by coiling it into a hold at the commencement; and more, that, whatever may be said, no cable has ever yet been laid, either by Messrs. Glass, Elliott, or others, which approaches such conditions as are here to be met. The Toulon and Algiers cable was only laid in pieces, so to speak. The first attempt took them nowhere; the second, as far as Minorca; and the third, from Minorca to Toulon. Is this such a success as ought to be or can be referred to, as promising another, in laying a cable across the Atlantic? Is the Red Sea a success? Is the Alexandria and Malta, laid in a continuous length across deep water? Ill-treated as it had been in a hold, they even now fear to work through it at the speed they would otherwise do.

No; if not this plan, then some better one—but let it at least be one which seamen can approve, not a clumsy attempt to overlay landsmen's difficulties with landsmen's expedients, which are discovered successively, after the cable is broken, to have been mistakes. I can compare the proceedings hitherto to nothing so well as the attempts at pulling (rowing, landsmen call it) of a greenhorn in a boat. He seizes an oar—possibly even adventures on the stroke oar, if he is not speedily ejected. Then his miseries begin—perhaps he catches a crab—probably he breaks his oar—and it is always the fault of somebody or something, not himself, that he does not succeed: at length some old seaman, pitying his troubles, "double banks" his oar, and teaches him practically the value of that turn of the wrist, which seems easy enough to look at, but nevertheless takes some time to attain.

Seamen, as a body, are generally very ready to communicate their knowledge to those who come among them from the land, more so than most professions or trades, but neither their goodwill, nor even the undoubted aptness and acquisitive talent of telegraphic engineers, can make it possible to compress the learning of years into the compass of a voyage or two, lasting each a fortnight or so. Such a space of time is barely sufficient to overcome the rebellion of the stomach, or to master the mysteries of the soup plate. A very clever fellow perhaps learns, in addition, not to hold on to a slack rope, nor to seek the weather gangway on dire occasions; but the greatest progress which can be expected is, after all, as in the case before us, that the tyro should have learnt how he can *not* do it, and be willing to confess that, after all, it is a nautical question how to carry out great operations at sea, which can only receive its proper solution from seamen.

To them, therefore, as represented by this Institution I turn for approval; and if they do sanction my labours, I have no doubt that the telegraphists will join us heart and hand in carrying to a really successful issue this magnificent work, which I firmly believe is yet destined to play its part, under Divine Providence, in the spread of that universal peace—of that knowledge of Him which shall one day "cover the earth as the waters cover the sea."

Friday, May 16th, 1862.

MAJOR-GENERAL THE HONOURABLE J. LINDSAY, M.P., in the Chair.

MILITARY TRAINING,

CONSIDERED PRINCIPALLY WITH REFERENCE TO THE MOST ADVANTAGEOUS ARRANGEMENT OF THE EXERCISES AND OCCUPATIONS OF INFANTRY SOLDIERS.

(*Being a Sequel to Lecture delivered on the 8th of March,* 1861, *on Military Training, considered principally with reference to the Measures adapted for the Development of Individual Excellence.*)

By LIEUTENANT-COLONEL A. CUNNINGHAM ROBERTSON,
1st Batt. 8th (The King's) Regiment.

In a Lecture which I had last year the honour of delivering in this place I enumerated ten different kinds of instruction which it appeared to me desirable that our infantry soldiers should receive, namely, instruction—

I. Individual Instruction.

1. In marching and setting-up drill.
2. In gymnastic exercises.
3. In the use of arms and intrenching tools.
4. In field cookery.

II. Collective Instruction.

5. In field exercises and evolutions.
6. In heavy gun drill and the management of artillery.
7. In the method of constructing trenches and batteries in the presence of an enemy.
8. In escalading.
9. In the method of pitching tents and of constructing huts.
10. In the method of using tackles, and in the modes of applying some of the simpler mechanical contrivances for moving heavy bodies.

I do not think it necessary to say a single word in order to prove that if it were possible it would be very desirable that all the different kinds of instruction I have enumerated should be given to our infantry soldiers; but whether or not that which is undeniably desirable can be proved to be practicable is a question which cannot be determined without careful investigation.

What I shall now attempt to do is to state to you as fully as possible my reasons for thinking, that, after making due allowance for interruptions occasioned by bad weather, sickness, and duties, and after also allowing ample time for repose and for keeping in order arms, accoutrements, clothing, and quarters, the remaining time available for the instruction of the

soldier is sufficient for the acquisition and practice of all the arts and exercises in which it is desirable that infantry soldiers should be proficient.

The three great branches of the training of an infantry soldier are,—

1st. Field exercises and evolutions.

2nd. Rifle shooting.

3rd. Gymnastic exercises.

In order to determine how much time must be devoted to these three branches, and how much will be available for other arts and exercises, we must consider what is the precise object of each kind of training, and the nature and amount of instruction necessary to enable a recruit to do the particular thing required with ease and accuracy.

Commencing with field exercises—the object of this branch of training is to enable the officer who commands a body of troops to form the line of battle in the most expeditious manner in any given direction, and to execute without confusion such changes of position or formation as may be expedient, either for the purposes of attack or defence. In order to enable an officer to guide the motions of a body of troops, each individual soldier must know the method of performing a variety of evolutions, and when particular commands are given must be accustomed to act in a certain prescribed way. Very different estimates will be formed by different individuals of the nature of the instruction and of the time required to teach the recruit to do this. If, in order to form the line of battle without confusion and with the utmost possible rapidity, it be necessary that soldiers should be trained to absolute precision of movement, if it be necessary that the length of pace and rate of movement of every individual soldier should be precisely the same; if this be necessary, then experience proves that such perfection of movement can only be acquired after a long course of most assiduous training, and that it cannot be kept up without constant and laborious practice; so constant and laborious that troops accustomed to move on parade and to handle their arms with perfect precision will have little time for any other occupation than the life-long, daily monotonous routine of squad, company, and battalion drill.

If, on the other hand, this absolute precision of movement be not essential; if it be found that in practice considerable looseness and irregularity of movement has no tendency to create confusion, and is perfectly compatible with the utmost rapidity and most perfect accuracy of formation; if it be found that this absolute precision of movement, which is so imposing and admirable on the parade ground, is by no means essential to efficiency in the field, then it is obvious that the process of teaching troops field exercises and evolutions will be completely divested of its laborious character; that after recruits have been drilled to act together, and have been taught the few and simple methods by which all possible changes of position and all useful changes of formation may be effected, comparatively speaking, very little time need be devoted to the practice of these methods.

It appears to me that to train soldiers on a system which aims at absolute mathematical precision of movement, so far from being necessary or even advantageous, is in its tendency absolutely injurious to their efficiency in the field.

In order to understand how it is that an apparent perfection is in reality an imperfection, let it be remembered that the conditions of warfare do not admit of the preservation of perfect, unbroken order in the formation of troops, nor of perfect mathematical precision in their movements. Now, if troops throughout the whole course of their training have been taught to believe that perfect regularity in their formations and perfect precision in their movements are essential to their efficiency, these troops, when for the first time they are placed in circumstances where a certain degree of derangement in their formations and of looseness of movement are unavoidable, are apt to imagine that such deviations from the precision of parade are evidences of mismanagement and failure. The more perfect the parade training of the troops the greater influence has the idea of their incapacity for acting together with effect under conditions which their parade training has never attempted to imitate. Commands which they cannot execute with their accustomed precision they scarcely attempt to execute at all. It is very possible that a highly-drilled battalion, which years of assiduous training in the art of parade evolutions had rendered the model for an army, might, when brought for the first time into contact with an enemy, be found more unmanageable and unhandy than an undrilled guerilla levy which had received no other training than such practical lessons in the art of united action as it might have picked up during a few months of warfare.

Of course a very little experience of campaigning teaches the regular as well as the irregular soldier that unity of action is perfectly compatible with broken ranks and with very considerable looseness of movement, but I myself have had more than one opportunity of observing that this is not one of the lessons which either officers or soldiers learn on the parade ground, and I should think that almost every officer who has seen troops led into action for the first time must be able to recall to his memory incidents which would serve to illustrate and confirm the observations which have just been made.

If, therefore, the method of executing battalion movements on parade was so modified as to be made to resemble as nearly as possible the manner in which the usual conditions of warfare render it unavoidable that these movements must be executed in the field, it appears to me that these modifications would not only render this part of a soldier's training simpler and more easily taught, but that it would also render it much more practical and serviceable.

Without attempting to go into the details of such modifications as might be suggested for carrying out this view, I shall merely, for the sake of illustration, indicate some of the expedients which might be made use of in order to accustom soldiers on parade to those irregularities and deviations from uniformity which must inevitably occur during field service, and in order to facilitate the management of troops when they are required to move loosely and with the order of their formation more or less deranged.

I. Companies should never be equalised when practising battalion movements.

In deployments, formations of columns, and echellon movements it

makes no practical difference in the mode of executing these movements whether companies be equal or unequal, but in symmetrical manœuvres, such as double-column movements and the formation of squares, when the companies are of unequal strength these evolutions cannot be executed with the same precision as when companies have been equalised. It seems particularly desirable that the formation of squares should always be practised with companies of unequal strength; because when squares are required to be formed in the field the troops have generally been some time under fire, many casualties have occurred, and the manœuvre has to be executed under conditions which render the symmetrical formations of the parade ground quite impossible.

II. Battalions should be practised in executing changes of front and other manœuvres by the successive as well as the simultaneous movements of companies, no general word of command being given, but the necessary caution being passed from company to company.

The manner of passing a command along a line, or from front to rear of a column, is a matter of considerable practical importance, it is a process which should be performed in a systematic manner and which should be frequently practised.

III.—In order to accustom troops to move loosely, battalions should be practised in deploying, with intervals between the companies equal to about a quarter of their front. The line should then be ordered to advance, the men of each company opening out on the march so as to fill up the intervals: at the word "halt" the men should instantly close on their right files. A loose movement should always be followed by a perfectly accurate formation. The instant a line halts, without further caution the coverers should move out four paces; they should then face to the right or left as might be ordered, and as soon as accurately covered the companies should move up in succession and dress. If the companies are ordered to commence firing immediately on entering the alignment, the coverers should move out the instant the "cease firing" sounds.

IV. The captain of a company ought to be required to exercise an efficient control and superintendence over the movements of his company; he ought to be required to correct the errors of his men, to check or accelerate their pace, to break off files, and to make such other changes in the order of their formation as may be necessary for the purpose of passing obstacles, to repeat words of command, and to see that they are properly obeyed.

To enable him to do these things he must be relieved from the duty of preserving covering and distance in column, and both in line and column permitted to use his own discretion in changing his place and going to whatever point may appear to him most convenient for superintending and directing the movements of his men. I believe when the drill-book was last revised Colonel Lysons was strongly urged by many officers to introduce the change suggested in the parade functions of captains of companies, but unfortunately could not be persuaded to do so.

When a strong battalion is moving over broken ground it is impossible for a commanding officer to keep the men properly in hand or to exercise an effective control over their movements without the active assistance of

captains of companies, and that assistance they cannot possibly render if they remain in the position and perform the duties assigned them by the present regulations.

To preserve covering and distance and to precede and guide a company should be the function of a serjeant told off for that especial duty. Each of these company guides should carry a small distinguishing flag, differing in form or colour from those of the other companies. These distinguishing pennons would be very useful as rallying points. In moving loosely in line over broken ground the guides should precede the line by two or three paces; and, however loosely and independently the men might be moving, they should be so trained that every individual soldier should carefully avoid getting in advance of the line of guides, and that all should look to these men for the regulation both of the pace and of the general direction of the movement.

Divisional field days on broken ground, such as the ground on which the Aldershot division exercises, are no doubt highly instructive to officers, but I am doubtful whether the private soldier, trained according to existing methods, can derive any benefit from them. The contrast between the loose movements, the disordered ranks, and the many irregularities of the divisional exercises, and the perfect precision of the drill on his own regimental parade, is so violent that he must either conclude that the looseness and irregularities of the divisional practice are the result of bungling, or else that the precision of his regimental training is utterly useless and absurd. I believe the former opinion is that to which the soldier usually inclines. He is apt to consider every deviation from the precision and regularity of a barrack square drill as a sign of failure and mismanagement. The impression made on his mind of what he has witnessed or performed during a scramble to the top of Cæsar's camp very often is, that his commanding officer or his general has made a mess of the business; and not unfrequently this opinion is partly consistent with fact, for when the natural difficulties of ground have deranged the formation of the troops, and made looseness of movement unavoidable, officers and men being alike destitute of any systematic training in the best method of preserving unity of action under these conditions, the men are often very clumsily handled, and even under the most skilful management are very difficult to keep together and to preserve from getting into confusion, which, let it be remembered, is a very different thing from looseness of movement or from the derangement of the regularity of a formation.

In order to make the Aldershot field days as useful to the private soldier as to the officer, the preliminary training which the soldier receives when a recruit ought to be arranged with reference to the circumstances in which he will be placed in the future field day. What recruits are at present taught is the art of moving on smooth ground, at a measured pace, without deranging the order of their primary formation; what they ought to be taught is how to move rapidly over any kind of ground, and, however much their formation may be deranged, to execute any manœuvres that may be required without confusion, being at all times prepared to close their files and form with accurately dressed ranks on any

given alignment. This is the way in which French troops manœuvre, as is noticed in the report of a professional visit to the continent by three artillery officers in August and September, 1861. They say:

The French appear to attach no importance to that precise and correct execution of a movement which we insist upon in our armies.

Squareness of movement is almost entirely unknown among them, and individuals as well as masses almost invariably move from point to point by the shortest and most expeditious modes.

In the depôt battalions of regiments of the line the recruit is drilled three times a day, the length of each drill being from an hour to an hour and a half; about two hundred of these drills are considered necessary before the recruit is fit to take his place in the ranks and to perform his share of guards and duties.

Three drills a day in summer and two in winter is the time which the instructed soldier is required to devote to the practice of field exercises in most regiments of the line. This amount of drill is not more than enough to ensure that precision of movement which is expected of a crack regiment on parade. But, if it be considered useless to require on parade a degree of precision which it is impossible to preserve in the field, a much smaller number of drills would suffice. Three drills a day for two months in the spring, one drill a day during the rest of the year, and one brigade field-day a week during the summer, would be amply sufficient to keep troops thoroughly efficient in their field exercises.

At Chatham, the recruits of the Royal Engineers receive pretty nearly the same amount of instruction in field exercises as recruits of the Line; but, after going through this course, one drill a week is found sufficient for practical purposes.

Volunteers can only be got together for drill purposes at irregular intervals, seldom so frequently as once a week; yet this scanty and irregular training, which includes both original instruction and subsequent practice, suffices to render a Volunteer battalion, when properly commanded, perfectly manageable and able to perform any required evolutions, not indeed with the same precision as it would be performed by a battalion of the Line on parade, but in precisely the same manner as a Line battalion would perform it on broken ground under the fire of the enemy.

When a battalion of the Line has been employed for two or three years on active service, during which parades for drill must often be suspended for long periods of time, it must be broken up into squads and thoroughly redrilled before the men are able to move on parade with the same steadiness and precision as they were accustomed to move before they took the field. Yet no one supposes that for practical purposes a battalion at the end of two or three campaigns is less efficient, less manageable, and less easily handled than before these campaigns commenced.

The next great branch of the infantry soldier's training is instruction in the use of his rifle.

The object of rifle instruction is, first, to teach the soldier to judge correctly the distance of a man placed at any point within a range of 900 yards; secondly, to teach him to hit any object fired at within that range.

The time allotted to this important branch of training is sixteen days

for the instruction of the recruit, and twelve days for the annual practice of the trained soldier, to which must be added, after the annual course is completed, one or two days a month judging distance-practice, and perhaps an equal number of days devoted to position-drill.

In order to exhibit the degree of proficiency which is attainable by this very limited amount of instruction, I requested Mr. Clarke, the schoolmaster of the 2nd battalion 8th (the King's) Regiment, to prepare from General Hay's Reports for the Years 1858-59-60 and 61 the annexed statement (*see next page*), showing the general results of the target practice of these four years.

From this statement it appears that there has been a pretty uniform improvement in the average figure of merit, which has risen from 28·31 in 1858 to 33·96 in 1861, being an increase of 5·65 in the four years, or rather less than a point and a half per annum.

But in the year 1860 the per-centage of marksmen and also of first-class shots is very much smaller than in any of the other years. It would be interesting to know if General Hay could assign any reason why these per-centages are lower while the figure of merit is higher than those of the preceding years.

If the returns of the year 1861 were accepted as a true measure of the maximum average results attainable by our present system of musketry instruction, it would follow that in every company we might reckon upon producing six marksmen, twenty first-class and fifty-three second-class shots; the average figure of merit of each instructed soldier, that is the number of points made in firing fifty shots at distances varying from 150 to 400 yards, being 33·96. These are the average results of the year's practice; but in a very considerable number of corps results were obtained which seem to indicate that in future years, when the system becomes better understood and more zealously worked, a very great improvement in this average may be expected.*

In thirty-two different corps the number of marksmen exceeded ten in a hundred; and in ten different corps between sixty-two and thirty-one men in every hundred were first-class shots. In the same ten corps the average figure of merit varied from fifty-one to forty-five points, that is to say, the ratio of points made to shots fired between 150 and 400 yards varied from 102 to 90 per cent.

Suppose such an improvement were to take place in the method of conducting our rifle instruction that the average shooting of every corps in the army became equal to the average of these ten corps, what an immense increase in the efficiency and destructive power of our infantry would this improved average represent!

I do not, indeed, put any faith in these calculations, which, from the data of the points made at target practice, deduce the exact number of men

* The publication of General Hay's report enables me to say that these anticipations of improvement have been fully realized by the progress made during the season 1861-2. Compared with the preceding year the number of marksmen has increased more than two and a third, and the number of first-class shots nearly five per cent., the number of third-class shots has decreased six per cent., the average figure of merit has risen nearly five and three-quarter points, and the number of corps in which the men classed as marksmen exceed ten per cent. of the strength has nearly doubled.

that an enemy will lose in passing over a given space at a given rate. But although we are not able at present, and perhaps never shall be able, to express in figures with mathematical exactness the precise relation that exists between skill at target practice and efficiency in the field, yet we may feel positively certain that a real relation does exist between skill and efficiency. We may feel most certainly assured that under all possible conditions (excepting, perhaps, rapid firing at close order and at short distances) the fire of a given number of marksmen will be more efficient than the fire of the same number of third-class shots. More than this, we may, I think, safely assume that when troops fire under cover at an exposed enemy the measure of the difference of efficiency of soldiers of different classes will be very nearly the same as the measure of the difference of their skill at target practice.

The following extract from a leading article of the "Times" indicates the nature of the relation existing between skill acquired at target practice and efficiency in the field, with that admirable force and perspicuity which, whatever may be the subject treated, is the invariable characteristic of any statement, whether of fact or of opinion, submitted to the

RETURN, showing the General Results of Musketry

DATE.	Total Number of					Per Centage of			
	Men instructed	Marksmen	Men in 1st Class	Men in 2nd Class	Men in 3rd Class	Marksmen	1st Class	2nd Class	3rd Class
1857—58	42·029	...	9·819	20·620	11·590	...	23·36	49·06	27·58
1858—59	69·632	31·37	19·566	33·450	16·666	4·50	28·09	47·97	23·94
1859—60	109·321	36·36	16·488	56·623	36·210	3·33	15·08	51·79	33·12
1860—61	124·588	72·45	25·666	66·852	32·070	5·81	20·60	53·65	25·74
1861—62	131·214	10·719	35·521	69·811	25·882	8·17	25·55	53·20	19·72

Note.—Since this Lecture was delivered, General Hay's Report for the Season 1861-62 has been published. This Report, for the first time, contains tables showing the general results of the practice of the season. These valuable and interesting tables will be found at pages 11—43 and 51 of the Report, and it is possible that the idea of compiling them may have been suggested by Mr. Clark's table, which was communicated by me to the Army and Navy Gazette, and published in it in December, 1860.

General Hay has very properly limited his abstract of results to the practice of the infantry. But as the practice of the cavalry and artillery was included in the table compiled for me by Mr. Clark, I have (for the sake of enabling an exact comparison to be made with

public by the editors of the leading journal. In the article from which I quote, it is said—

Nobody expects that every shot fired by every marksman will always go as true as the shot fired at a target in a competition for prizes. But even imperfect results have their value. The object of proficiency in rifle shooting, as in all other pursuits, is to secure the highest possible average in common practice.

The First Battalion 22nd Foot enjoys, we learn, the distinction of being the best shooting battalion in the whole army. It is not in the least degree probable that in actual service the figure of merit of this regiment would be what it is in practice at home, but we should, nevertheless, feel very certain that the rifles of this regiment would, under equal conditions, do more execution than the rifles of any other regiment.

The only way, in short, of securing good average proficiency is to practice for peculiar excellence. The practical results will, of course, fall short of the specimen exhibitions, but its value will be in a direct ratio to the proficiency so acquired. The nearer our troops are brought, as a body, to the class of first-rate shots by practice at home, the more formidable will they be as a body against any enemy in the field. It may be quite true that in the heat of action a soldier will not think of recurring to any of the little distinctions he has learned on parade, but it is equally true that the training he has received will produce its effects, although it may be mechanically, and that his firing will be infinitely more effective than that of a man who has had no training at all.

INSTRUCTION FOR THE YEARS 1858-59-60-61 and 62. (*Referred to in page 503.*)

Figure of Merit			Number of Men recommended for Rewards.	Amount distributed in Musketry Premiums						Number in excess of Authorised Numbers.	No. of Corps in which Number of Marksmen exceeded 10 per cent. of number who fired.
				Total Sum			Average for each Man Instructed				
Highest	Lowest	Average		£	s.	d.	£	s.	d.		
39·08	14·59	28·31									
41·84	15·08	30·37	27·41	5,263	12	1	0	1	6¼	128	17
45·95	12·07	31·51	32·00	6,348	19	0	0	1	2	122	6
51·66	16·93	33·96	59·67	15,287	8	4	0	2	5½	956	32
54·40	26·08	39·69	84·05	15,199	4	2	0	2	3·8	1,827	59

the results of the practice of former years) included cavalry and engineers in the Abstract of the Practice of 1861-62 which I have added to Mr. Clark's table. This has the effect of somewhat lowering the per-centage of the marksmen and first and second-class shots, and of increasing the percentage of third-class shots, given at page 11 of the Report. Excluding cavalry and engineers the number of infantry instructed was 121,423

And the per-centages were, Marksmen . .	9
1st Class	27
2nd Class	55
3rd Class	18

If this be a correct representation of the nature of the connection subsisting between the proficiency of troops in their rifle training and their efficiency in the field, it becomes an important question whether or not it would not be advantageous to devote more of the soldier's time to rifle practice.

It may, I think, be assumed as certain that increased efficiency would be the result of every additional hour and of every additional round devoted to rifle practice; but the limited extent of ranges, and the expense which would attend a large increase in the expenditure of practice ammunition, are practical difficulties which would oppose any attempt to improve the efficiency of our training by increasing the number of days devoted to it. I cannot, however, help thinking that, instead of concentrating within twelve days or a fortnight the whole amount of each man's annual practice, it would be advantageous to spread it over the whole of the drill season, and to make arrangements that every soldier in the Army for thirty weeks in the year should fire three rounds a week. Arrangements might also, I think, be made for allowing marksmen to perfect themselves in the use of the rifle, by allowing them to draw as much ammunition as they choose to expend in voluntary extra practice.

Even without increasing the amount of the soldier's training, it is probable that a great deal might be done by using additional means to stimulate him to use every exertion to make the most of his opportunities. Every possible means should be used to make the attainment of excellence in rifle shooting the great object of his ambition. In my former lecture I pointed out, as a means for attaining this end, the great importance of ensuring to every man, who reaches that degree of efficiency which constitutes the qualification to be classed as a marksman, the right to wear the badge and draw the extra penny, which right, according to existing regulations, is in each particular corps, limited to 10 per cent. of the strength of that corps. The great importance of this change cannot be too frequently or too strongly insisted on. As the general proficiency of the troops increases so does the number of individuals increase whose interests are affected, and whose zeal is damped by the operation of this most impolitic rule.

In the years 1859-60 and 1861 the proportion of marksmen to the number instructed, and the number of men ineligible for rewards in consequence of the per-centage of marksmen in the particular corps they belonged to exceeding the prescribed limit, was—

Years.		Per-centage of Marksmen.		Number Ineligible.
1859	..	4·50	..	128
1860	..	3·33	..	122
1861	..	5·81	.	966

Out of 124,588 men instructed in 1861, although only 5,967 on 4.79 per cent. received rewards, yet 956 marksmen were returned ineligible because in excess of 10 per cent. That is, out of every seven men qualified one was disappointed of his reward.*

* In 1862 the number of men recommended for rewards is less than six and a half per cent. of the number instructed, and, out of every forty-seven men qualified, ten were disappointed of their rewards, because they happened to belong to corps in which the number of marksmen exceeded ten per cent. of the strength.

There is another slight alteration in existing arrangements which would, I think, have a very considerable effect in increasing the interest felt by the soldier in musketry instruction. Instead of determining the best shot of the battalion simply by reference to the practice returns, I think that the two best shots of each company should be selected, and the best shot of the battalion determined by a special match between these twenty men. Every shot fired in this match should be marked in a diagram, a copy of which, neatly mounted and varnished, should be hung up over the bed of the winner. If the best shots of battalions could be pitted against one another at divisional and national matches, of course the interest would be intensified in the same degree that the sphere of competition was enlarged, and the celebrity acquired by success more widely extended.

I now proceed to offer some observations on gymnastic exercises, the third great branch of military training.

Gymnastic exercises are not practised for the same reason that we practise firing at a target with a rifle. Skill in the use of the rifle is most valuable to a soldier, it adds greatly to his efficiency, and it is solely because we desire our soldiers to acquire this skill that we cause them to practice rifle shooting. This is our sole motive, we do not look for any indirect and ulterior advantage.

But, excepting on special occasions (such as an escalade), the power to vault over a bar, to climb a pole, or to perform any of the exercises practised in the gymnasium, is not likely to be of much practical value to a soldier. It is not, therefore, solely, or even chiefly, for the sake of teaching the soldier to do these particular things that a large portion of his time ought to be devoted to gymnastic training, but chiefly because this training is the best means of developing the power of his muscles, of giving strength and suppleness to his limbs, and of increasing the force and agility of his movements. The immediate object of gymnastic training is not therefore to teach certain specific exercises, but to increase the general energy of the bodily powers, and to communicate perfect facility in all possible modes of exerting these powers.

The increased efficiency for military purposes which results from the accomplishment of this object is obvious. The same reasons which, in the selection of recruits, make us anxious to obtain the strongest limbed and best proportioned men we can find should, after a man is enlisted, make us equally anxious to use every possible means to increase and develope his strength.

The majority of infantry soldiers are by no means picked men; very many of them have been brought up in towns, under conditions not at all favourable to health. Such men are much inferior in physical power to the generality of men belonging to our agricultural population. Moreover, the routine duties and ordinary mode of life of soldiers are unfavourable to the development of muscular power. It is only by the assiduous practice of gymnastic exercises that soldiers can acquire that bodily vigour which sailors and agricultural labourers, and several descriptions of artizans acquire by the exercise of their daily occupations. A man thoroughly trained in the exercises of the gymnasium not only developes his muscular powers to the utmost extent permitted by his organisation, but he acquires perfect facility in applying his strength in

the most advantageous manner to whatever purpose it may be his object to effect; and this facility in a personal struggle will generally enable him to obtain the advantage over an untrained adversary very much his superior in bodily strength.

The increased power of endurance and capacity of exertion which are the results of gymnastic training are not, however, the only nor even the chief advantages to be derived from it; of far more consequence than these physical results are the moral effects produced by the consciousness of the new capabilities, and of the increase of power that has been acquired. The consciousness felt by the soldier that he is now able to do many things which a short time before he was unable to do; that in agility and force he now feels himself superior to many persons to whom he formerly felt himself inferior. The consciousness that this superiority is due to his having had the advantage of a special military training, the want of which renders the civilian inferior to the soldier. From this consciousness of superiority and conviction of the possession of special advantages directly originate those feelings of confidence and self-reliance which are the mainspring of daring deeds.

According to our present system of training, the only special advantages possessed by the soldier are his arms and his discipline. Deprived of these the majority of infantry soldiers possess no natural advantages; no special training on which to ground feelings of confidence and self-reliance. They are not picked men. Their ordinary occupations and exercises are not favourable to the development of bodily vigour. In guerilla warfare with a hostile rural population, and in wars carried on with savage or with half civilised tribes, the soldier generally feels that in a personal conflict he is no match for his adversaries. As long as the force of which he forms part can maintain the ranks unbroken he looks upon such adversaries as despicable, and confronts them with full confidence of success. But very different are his feelings if—surprised by some sudden onset—his ranks are broken, and he finds himself obliged to struggle single-handed with a foe superior to him in strength and agility. From such encounters the regular soldier instinctively shrinks; physically he is over matched; morally he is destitute of those feelings of confidence and self-reliance which are even more essential to success than superior physical strength.

In modern warfare, carried on by the regular armies of European nations, we have, until very recently, had no means of judging of the influence of gymnastic training in generating self-confidence and stimulating to daring deeds. But the signal services rendered by the French Zouaves, and the great reputation acquired in the Crimean and Italian campaigns by these and other specially trained soldiers, seem to prove that gymnastic exercises are the most important part of a soldier's training, and that proficiency in these exercises is more important than precision in drill, more important than even skill in rifle shooting.

Such is the testimony as to the estimation in which gymnastic training is now held in France, recorded by Lieut. Steinmetz in the interesting paper contributed by him to the Journal* of the Institution. He says:—

* Vol. v. p. 381.

The admirable precision sometimes exhibited in some crack regiments will be as nothing in the field of battle compared with the training which will keep soldiers always in condition, and give them not only a ready and constructive use of their intelligence, but also the utmost nimbleness of motion and hardihood of which they are capable.

The Report recording the information concerning the state of the principal continental armies collected by the three artillery officers who visited the continent in September, 1860, confirms the testimony borne by Lieut. Steinmetz as to the great importance now attached to gymnastic training, not only by the French but by the Russians.

The Report says:—

In every country great attention is paid to the setting up and physical improvement of the soldier. Nor do these exercises cease on the recruit becoming a duty man, but continue to be regarded as a part of his drill, and practised throughout his service. In Russia this is more especially the case, the other drills being constantly and pleasantly varied by gymnastics.

Gymnasiums are attached to every regiment, and although no prizes are given, or means taken to reward proficiency, yet the men are very fond of their exercises, and a spirit of emulation appears to exist among them, which must greatly facilitate the task of the instructor.

The Report contains an account of a review at Warsaw which is particularly interesting.

A high wooden castle front with three tall towers rising from it, and obstacles disposed in front, was assaulted by three columns of soldiers dressed in white canvas frocks, and carrying their arms and accoutrements.

The obstacles passed by the right column were—

1st. A deep ditch.

2nd. A high slippery slope of plank inclined at an angle of about 45° with a 10-foot perpendicular drop from the summit.

3rd. A parapet and ditch.

4th. Another ditch with palisades.

5th. A glacis with a deep ditch 18 feet broad, and row of palisades down the centre.

Obstacles of equal difficulty were passed by the other two columns, the soldiers displaying a remarkable amount of agility and readiness in surmounting them.

The moral influence exerted by the development of the bodily powers appears to have forcibly impressed a Prussian officer, whose description of a French chasseur is quoted by Lieut. Steinmetz. He says,—

As they flit about with astonishing rapidity, you recognise their enterprising spirit, their daring pluck, their quick intellect, their indefatigable endurance.

If these representations of the value of gymnastic training be accepted as correct, then the necessity imposed on us to secure to our soldiers the same advantages as are possessed by the French and other nations who have introduced this training into their military system is not less imperative than the necessity which has compelled us to follow the example of the French in protecting our ships of war with iron plates.

Inferiority of training will compromise the safety of any army, not less

inevitably than inferiority of materials will compromise the safety of a fleet.

Gymnastic training possesses the peculiar advantage of being not only exceedingly useful, but also exceedingly interesting and attractive. It is notorious that the stiff monotonous exercises of the parade ground are intolerably irksome to those who practise them, and although that part of rifle instruction which consists of target practice is interesting and exciting, yet this is preceded by a tedious drudgery of position drill, which is so tiresome and uninteresting that it has a strong tendency to render the whole process of instruction disgusting and unpopular.

Among the young and the healthy, with the exception of a few men of unusually sluggish and apathetic disposition, gymnastic exercises are invariably popular. There is no preliminary drudgery to be gone through. The first exercises of the novice are as interesting as the exercises of those in the most advanced stages of training. Both in its earliest and in its most advanced stages, the training process consists of efforts requiring the most energetic exertions, which, after being persevered in for a greater or less number of times, are certainly followed by successes producing a most delightful and animating effect on the spirits.

This is precisely the kind of occupation adapted to gratify that instinctive impulse which renders every species of activity pleasing to the young. Practised alone by a single individual, gymnastic exercises would be attractive as an interesting daily occupation, but, when practised systematically and in classes by a large body of young men, the interest of these exercises is capable of being intensified to a very high degree.

To render the desire of excelling in them an object of ambition and of strenuous exertion to the great majority of young soldiers, all that is necessary is to establish periodical trials of skill, so arranged as to embrace the whole army in its sphere, and to afford to every individual soldier the opportunity of proving himself the best man at some particular military or gymnastic exercise; first, in his own company; second, in his own regiment; third, in the camp or garrison in which he may be serving; and, finally, in the whole army.

I gave some details in my former lecture showing how such a system of periodical trials of skill might be arranged at an expense not exceeding seven pence per man of the strength of the army. It is unnecessary to repeat these details of an organisation which might be varied in many ways. But I am anxious to take this and every other opportunity of repeating what I then said respecting the important results that would be obtained by adopting, as an integral part of our system of military training, such an organisation based on the principle of discriminating and rewarding individual excellence.

I am convinced that if soldiers were stimulated by the hope of obtaining high distinctions to use their utmost efforts to excel in those exercises which develope the bodily qualities of agility and strength, and the mental qualities of daring and self-reliance, so great an effect would be produced in the feelings and in the capabilities of soldiers as would amount to a complete change both in the moral and physical constitution of the army; converting it, from a body of men feeling little interest in

their duties, and possessing no special aptitude for physical exertions, into a body of trained athletes strongly interested in their daily occupation, and animated by feelings of emulation and the desire of excellence.

The effect of awakening these feelings would be, not merely to ensure proficiency in military and gymnastic exercises, but also to exert a most salutary moral influence on the character of our soldiers—an influence which would counteract, or which would at least be antagonistic to, those evil influences which are the result of idleness and the want of any beneficial and interesting occupation.

Parliament might very likely refuse to vote money merely for the purpose of effecting improvements in military training, the importance of which might not be fully appreciated by any excepting military men; but if Parliament could be convinced that the same means which are essential to the perfect military training of the soldier are also the best that could be employed for the improvement of his moral character, it is certain that the necessary funds would be freely voted.

There is never any hesitation in voting considerable sums for military schools and for good conduct rewards. Is there no one to point out to Parliament that the benefit of money spent in this way is confined to a limited class, and that the same amount of money spent in establishing a system of training adapted to promote the developement of individual excellence would exercise a beneficial influence on the whole mass of soldiers composing the army, and would bring every individual belonging to that mass under the direct operation of a powerful means of moral improvement?

Concerning the time necessary to devote to gymnastic exercises, Major Hammersley considers that, during the whole period occupied in training recruits, one hour a-day should be spent in the gymnasium. The course of instruction there given to the recruit would include exercises with dumb-bells and the ladder plank, adapted to effect the process of setting up in a manner far more efficient, and also far more agreeable than it can be effected by the usual means of extension motions and club practice.

The recruit would also be practised in walking, running, leaping, vaulting, climbing, escalading, and in the various exercises performed by means of the machines of the gymnasium.

At the end of a three months' course even the most backward recruit would be able to perform all the exercises included in Course III. of the system of military gymnastics which has just been issued by the Horse Guards, and in every squad there would be many who would be able to accomplish the greater number of the advanced exercises included in Course IV.

After the recruit was dismissed drill, Major Hammersley considers that one hour a week would be sufficient to keep up the power of performing whatever exercises he had mastered before, while, if one or two hours in the gymnasium formed part of the regular daily routine of the exercises practised by the infantry soldier, progress would continue to be made until in the course of a year or eighteen months each individual soldier would attain the maximum amount of power and skill of which his organisation was capable.

Major Hammersley estimates that with this amount of training two-

thirds of each squad would be able to perform all the arduous exercises included in Course V. of the book.

To give an idea of the degree of muscular development produced by gymnastic training, Major Hammersley has been good enough to furnish me with a table showing the results attained during one year's training in the Experimental Gymnasium at Aldershot.

By this it appears that during these twelve months 1,800 men received instructions, but of this number only 1,363 completed a three months' course, during which time, out of a total of thirty-six lessons, the average amount of instruction received by each man was only nineteen lessons of one hour each.

The average muscular development produced by these nineteen hours exercise was, increase of measurement of chest from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches, of fore arm from $\frac{1}{2}$ to $\frac{5}{8}$ of an inch, and of upper arm from $\frac{3}{4}$ to $\frac{7}{8}$ of an inch. The maximum increase recorded at Aldershot was,

Chest . . .	4 inches
Fore Arm . . .	$\frac{3}{4}$ "
Upper Arm . .	$1\frac{3}{8}$ "

During five months' training at Oxford the increase of one of the Aldershot instructors was,

Chest . . .	5 inches
Fore Arm . . .	1 "
Upper Arm . .	$1\frac{3}{4}$ "

The conditions under which gymnastic training is carried on at Aldershot are by no means favourable for testing the amount of interest which soldiers might be induced to feel in this training; squads from every regiment in camp are marched down to the gymnasium at appointed hours, for a certain number of days; but, excepting the superintendent himself, I believe that no one exercises any supervision over the instruction which is there given to the men, or takes any cognizance of its success or failure. Commanding officers are naturally indifferent to an exceptional training which will never be repeated—which they know leads to nothing and will not be taken into account by the inspecting general in his confidential report. Individual officers who feel an interest in the experiment occasionally visit the gymnasium to see how their men are getting on, but no systematic regimental record is kept of the amount of progress made by each individual, neither are any means taken to ascertain the comparative efficiency of the detachments of different corps. In short, no means whatever are used to excite an interest in the experimental instruction, and to attract attention to its results.

It is obvious that men cannot be expected to take the same degree of interest in training carried on in this way that they would probably take if a different system were adopted,—if, for instance, at the termination of each course, previous to a squad being dismissed, it were inspected by the brigadier, attended by the commanding officer of the corps; and if periodical competitive trials were established, and small prizes distributed to those who during the course had acquired the greatest skill and proficiency.

Notwithstanding the absence of any attempt to render gymnastic training attractive by measures of this kind, there is sufficient evidence to show that it is popular among the men.

With few exceptions, every man who attends the gymnasium is a volunteer. The great majority of those who receive instruction manifest much interest in the exercises, they work hard and vie with one another who shall make most progress. After a squad is dismissed a good number of the men quartered near the gymnasium continue to frequent it at an hour when it is open to all who have gone through the regular course.

I have prepared the annexed table for the purpose of showing that it is possible so to distribute the time available for training as to allot a sufficient portion of it to each of the different exercises which it is necessary should be practised in order to render an infantry soldier thoroughly efficient in the field. *(See next page)*.

Throughout the year one day per week has been allotted to the inspection of kits, and to fatigue. On each of the other five days of the week the number of hours considered available for training, during the spring, summer, and autumn months, *i. e.*, from 1 March to 31 October, are—

From 7 A.M. to 8 A.M.	1	hour
„ 9 „ to 1 P.M.	4	„
„ 2 P.M. to 4 „	2	„
Total	7	hours.

During the winter months, that is, from 1 November to 28 February, the hours considered available are—

From 9 A.M. to 1 P.M.	4	hours
„ 2 P.M. to 3 „	1	„
Total	5	

Calculated according to this distribution, and deducting one-third from each total on account of interruptions from bad weather, guards, sickness, &c., the amount of annual practice devoted to each branch of training will be,

Company and Squad Drill	60	hours
Battalion ditto	160	„
Brigade ditto, 18 days	72	„
Route Marching, 12 days	48	„
Musketry Instruction	296	„
Gymnastic Exercises	290	„
Gun Drill	110	„
Other Exercises	75	„
Total	1,111	

Under the head of musketry instructions I include the practice of the manual and platoon exercises, and under that of gymnastics, setting up drill, the bayonet and sword exercises, and the method of using tackles, and of applying some of the simpler mechanical aids for lifting and moving

TABLE showing Number of Hours per Day, per Week, and per Annum available for the Practice of different kinds of Military Exercises.

Description of Exercise	Spring Practice, March and April							Summer and Autumn Practice, May to October							Winter Practice, November to February							Annual Practice	
	Hours per Day					Hours per Week	Hours in 9 Weeks	Hours per Day					Hours per Week	Hours in 26 Weeks	Hours per Day					Hours per Week	Hours in 17 Weeks	Hours in 52 Weeks	Do. do. deducting $\frac{1}{3}$ for Interruptions
	Monday	Tuesday	Wednesday	Thursday	Friday			Monday	Tuesday	Wednesday	Thursday	Friday			Monday	Tuesday	Wednesday	Thursday	Friday				
Squad and Company Drill	2	2	2	2	2	10	90	...	...	...	...	...	...	...	...	...	...	...	...	...	...	90	60
Battalion Drill	1	1	1	1	1	5	45	...	1	1	1	1	4	104	1	1	1	1	1	5	85	234	160
Brigade Drill............	...	...	...	...	...	...	...	4	...	...	...	...	4	104	...	...	...	...	...	...	...	104	72
Route Marching	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	...	...	...	...	4	68	68	48
Musketry Instruction..	2	2	2	2	2	10	90	1	2	2	2	4	11	286	...	1	1	1	1	4	68	444	296
Gymnastic Instruction	2	2	2	2	2	10	90	1	2	2	2	1	8	208	...	2	2	2	2	8	136	434	290
Gun Drill	...	...	...	...	...	...	...	1	1	1	1	1	5	130	...	1	...	1	...	2	34	164	110
Other Exercises.........	...	...	...	...	...	...	...	...	1	1	1	...	3	78	...	...	1	...	1	2	34	112	75
Total	7	7	7	7	7	35	315	7	7	7	7	7	35	910	5	5	5	5	5	25	425	1,650	1,111

heavy bodies. This instruction, Major Hammersley agrees with me in thinking, might be very easily and advantageously included in a course of gymnastics.

Under the head of other exercises I include field cookery, pitching tents, constructing huts, and whatever instruction it might be possible to give, without actually breaking ground, in the use of entrenching tools, and in the method of telling off working parties.

For instructing soldiers in the art of field cookery the most effectual plan would be, once a week during the fine season, to cause the men to pile arms on the ground where they usually exercise, and to cook their breakfasts and dinners in the open air. A cooking shed should also be attached to every guard house, in which the men on guard should be ordered to cook their rations.

A master cook, trained in a model kitchen, and thoroughly conversant with the most approved systems, both of cooking in the field, and of cooking by the aid of permanent ovens and boilers, should be attached to every battalion. The duty of the master cook would be to train a cook for each company, and to exercise a general superintendence over the cookery of the battalion. The company cooks would be required to instruct and superintend assistants selected by the rollster for a week's tour of kitchen duty.

After conversing on the subject with Colonel Harness, Colonel Simmons, and other engineer officers, I have become convinced that no instruction of any practical value can be given to troops in the use of entrenching tools, and in the method of constructing trenches and batteries, unless work with the pickaxe and shovel be actually performed.

To exercise the whole of the infantry in work of this kind merely for the purpose of instruction in the same manner that the Royal Engineers are exercised, would involve so great an expenditure in tools and working pay, that the advantages to be derived from such instructions would not be worth a tithe of its cost. The only practicable way of training infantry to the use of entrenching tools is, therefore, to employ military labour to the utmost possible extent for the execution of military works, such as draining, road making, levelling, constructing earthen ramparts, &c. Whenever works of this kind are to be executed one or more regiments should be placed at the disposal of the engineers' department to be employed as labourers. During the time a regiment was so employed its gymnastic training might be altogether suspended, and each of its companies might be relieved from work in succession for rifle instruction. One day a week would suffice for practising field exercises, on which day it would be necessary to relieve the whole corps from work either in the forenoon or afternoon.

It will be observed that in the table I have allotted a very large portion of the soldier's time to gymnastic exercises and to rifle training.

I believe that the time so allotted could not be more beneficially employed, and I also believe that by judicious management most soldiers might be induced to take a great interest in these branches of their training, and to devote much of their time to them without weariness.

I am, however, very far from considering it either necessary or desirable that all soldiers should be obliged to devote the same number of hours

a-day to these exercises. Whether the process of learning be esteemed agreeable or irksome, often depends more in the manner of teaching than in the nature of the thing taught, and there can be no greater mistake in a system of training than to require the skilful to perform the same exercises and to practice them for the same length of time as the unskilful. Marksmen, and soldiers able to perform all the gymnastic exercises included in the prescribed course, should only be required to practice at the rifle ranges and in the gymnasium for such a time and in such a manner as experience might prove to be necessary to keep up this skill.

Having now attempted to show that there is sufficient time available for the soldier to practice all the arts and exercises in which it is desirable he should receive instruction, I shall make a few observations on the nature of the amusements and occupations most suitable and advantageous for soldiers to engage in during their leisure hours.

I shall endeavour to show that, if it be possible, soldiers should be induced to select certain kinds of amusements and occupations in preference to others, which, though of a higher order, have a tendency to create tastes and habits inconsistent with attachment to military service.

A taste for study and for sedentary occupations has an excellent effect in preventing the formation of idle and dissolute habits, but it is apt to render a person sluggish and averse to active bodily exertion. It is therefore desirable that soldiers should prefer out of door sports, such as cricket, hand-ball, hockey, foot-ball, &c., to the in-door recreations of reading, chess, draughts, &c.

Industry, frugality, and prudence are most admirable qualities, but, if we adopt measures calculated to promote the formation of these qualities, we shall find that these same measures tend to destroy that love of adventure, that desire of personal distinction, that recklessness of consequences which distinguish the daring soldier from the sober citizen.

The incompatibility of frugal and industrious habits with those tastes and feelings which are essential to the love of military service has always appeared to me a strong objection to plans for the formation of regimental workshops, and I am surprised that the force of this objection does not seem to have been felt by any one of the many distinguished soldiers who advocate and promote these plans.

It has always appeared to me that the injury done to the military spirit of the soldier would be in proportion to the success of their plans in effecting a reformation in his moral habits. A soldier who in acquiring a trade had also acquired the frugality and prudence, and the desire to save money and to better himself in the world, which are the characteristics of an industrious tradesman, would, I think, inevitably imbibe a distaste for his military duties, and would eagerly seek for an opportunity of quitting the service. On the other hand, where the plan failed in its moral effect: In those cases where an idle and dissolute soldier acquired skill in a trade without his habits and tastes having undergone any change, he would merely have acquired a means of obtaining money to squander in drunkenness and dissipation.

Whether successful or unsuccessful in promoting the moral improvement of soldiers, the operation of the plan would inevitably be injurious to their military efficiency. Now, if an army is to be maintained at all,

military efficiency ought certainly to be the first consideration. The value of any particular amusement or mode of employing the leisure time of soldiers ought therefore to be estimated chiefly and primarily with reference to the effect it is likely to have on their military efficiency, and, if reference be made to the influence it is likely to exert in promoting their moral improvement, this ought only to be treated as a secondary and collateral consideration.

The first enquiry regarding any proposed method of occupying the leisure time of soldiers must be :—Will it promote their military spirit and increase their attachment to the service? and it is only after this question has been answered in the affirmative that we are permitted to enquire:—Will it tend to prevent the formation of dissolute and drunken habits? Arranged according to this principle of estimating their value, the different methods of providing occupation for the leisure time of soldiers may be thus classified:

1. Military and gymnastic exercises, such as rifle shooting, running, leaping, vaulting, climbing, &c.; though all these should be included in the regular routine of a soldier's training, yet means should also be taken to induce him to devote a portion of his leisure time to their voluntary practice;
2. Out of door amusements, such as cricket, football, &c.;
3. Attendance at the regimental school, and at instructive lectures, especially on military subjects;
4. Social amusements, such as amateur theatricals, concerts, &c.;
5. Sedentary recreations, such as reading, chess, draughts, &c.;
6. Industrial occupations.

I shall now venture to submit to you a few conjectures respecting certain modifications in the order of formation and method of handling infantry in the field of battle, which I think it may very possibly be found expedient to adopt in consequence of the change which will be introduced into the conditions of attack and defence, by arming infantry soldiers with weapons of vastly increased accuracy and range, and, by means of careful training, teaching them the art of using superior weapons in the most skilful and effective manner.

The obvious result of these measures, and of the substitution of rifled artillery for smooth-bore guns, will be to render it far more difficult and dangerous for a soldier to close with his foe than it ever was before. He will be exposed for a greater length of time to a more effective fire. When the defence of a position is conducted under conditions favourable to accuracy of aim, the loss suffered by the attacking troops will be so severe that the advance of the boldest soldiers will frequently be checked.

It may, therefore, be expected that close combats will become less frequent than ever, and that the average distance which separates contending armies will be greater than it used to be. Every movement will extend over a greater space, and will require a longer time for its completion. If flank movements, or extensive changes of position, are attempted, the whole day will be consumed before the attack is sufficiently developed. Protracted defence will become easier; rapid attack more difficult; decisive results will more seldom be attained.

Success will, in a great measure, depend on the possibility of making

such arrangements as will secure to troops the advantage of fighting under conditions favourable to accuracy of aim. To secure this advantage in the greatest possible degree, two expedients suggest themselves as likely to be employed, first, the creation of artificial cover by the indefatigable use of the pickaxe and shovel ; and, second, the substitution of a looser order of battle for the present formation of two ranks at close order.

Not only may it be expected that, in making even the most hasty arrangments for the defence of a position, rifle pits and such parapets as can be thrown up in a single night will be considered indispensable, but it even seems probable that it may be found impossible successfully to attack a position so strengthened without resorting to methods similar to those which are made use of in approaching a fortress. On the night before a battle it is possible that it may be found necessary to push forward working parties, and to provide cover for riflemen near enough the enemy's position to reach the hostile batteries with their fire.

Instead of positions being assailed and defended by infantry formed in two ranks at close order, it seems also probable that a more effective fire will be obtained by adopting a looser formation, so as to admit of the front and rear rank men changing places, each soldier delivering his fire in the front rank, and then falling to the rear to load.

This could easily be managed by deploying with intervals between the companies, so as to admit of the files opening out from the right to the extent of a pace, or half a pace, when the firing commenced.

In order to obtain the greatest possible results from the fire of skirmishers, it will probably be found that, instead of extending one or more complete companies, it will be better to employ none but marksmen and first-class shots in this important duty. Those belonging to every company in the battalion being ordered to the front, under the superintendance of a field officer, assisted by the musketry instructor, or by any other officer who might be selected as specially qualified for the duty. If only a few men were required, or if the enemy were barely within rifle range, only marksmen would be employed. If a greater extent of ground had to be occupied, or if the enemy were closer at hand, the marksmen might be reinforced by the first-class shots of one or more companies.

Similar arrangements might be made for defending an intrenchment. At first, while the attacking force was distant, none but marksmen should be allowed in the banquette. As it approached, the first-class shots might be ordered up, and for the defence of the last 300 yards the fire of every man in the ranks should be employed.

To check the advance of cavalry a line of company squares would, I think, be found preferable formations to the ordinary battalion square.

In a battalion of ten companies the front of the line of company squares would exceed the front of the two end faces of the battalion square in the ratio of ten to four, and that of the side faces in the ratio of ten to six, or, allowing for the flank men of the two front and the two rear companies, say in the ratio of ten to seven. In a battalion of eight companies these ratios would be eight to four and eight to five, and in a battalion of six companies they would be six to four and six to three.

The efficiency of the fire of the line of company squares would admit of being very greatly increased by causing the marksmen belonging to the

rear sections of each company to run out a few paces on the flanks, and thus to fill the intervals between the squares by a line of skirmishers who, as the cavalry approached, would resume their posts in the squares from which they had been detached. In case of the cavalry charging home, it would probably be impossible to prevent the horses from swerving and passing through the intervals, but even if they did succeed in breaking and riding over one or two of the squares the formations of the others would remain unbroken.

The same change in the conditions of warfare which renders it so advantageous that troops should fight as much as possible under cover and in the formation most favourable to accuracy of aim, renders it scarcely less important and advantageous that they should be so trained as to be able to move with rapidity, and to traverse long distances in a short space of time. The quicker they move while under fire the fewer will be their casualties, and the greater the distance to be traversed the more important does it become that the time of passage should be as short as possible. Moreover, since a few minutes difference in the time of the arrival of supports is very frequently that which determines whether an effort shall be successful or a failure, it is obvious that, if it be necessary on account of the increased range of projectiles to make dispositions which increase the distance supports have to traverse, it is a matter of the most essential importance that the rapidity of the pace at which the supports move should be accelerated to the greatest attainable speed.

I believe that the superiority of the French to the Austrian troops in the power of rapid movement was one of the chief causes of the successes obtained by the Emperor in his late Italian campaign; and I cannot conclude this lecture in a more appropriate manner than by reading to you an extract from a very interesting letter, addressed to Major Hammersly by Major Adams of the Royal Military College, in which are related several notable instances of most essential services rendered to the cause of the Emperor by the rapidity with which particular corps moved from point to point. Major Adams, relying principally on the statements of foreign writers, says:—

At Montebello two battalions, having previously taken off their knapsacks, advanced at the double to Forey's support, from Voghera to Fozzagazza, a distance of four and a half miles.

At Magenta the Division Renault, leaving their knapsacks behind them, completed the distance from Trecate to Ponte Nuova di Magenta, a distance of nearly seven miles, at a running pace (pas gymnastique), entering the line of fire immediately on its arrival.

In the same battle, on the French left, two battalions of Turcos doubled from Casate to Buffalora, 3,000 paces, to Lamotte Rouge's support. Similarly la Garde Voltigeur (Camon) from Turbigo to Buffalora, five and a half miles.

At Solferino towards the close of the day, when Niel was so hardly pressed, Canrobert, after inexcusable delay, detached the Division Renault from Medole to his support. The whole division, leaving its knapsacks behind, doubled to its destination, nearly two miles.

In almost all the cases cited, the opportune appearance of the supports at the decisive point, turned the issue of the different actions in favour of the French. Their columns of attack habitually advanced at the double from the moment they came within range of their adversaries' rifles (800 to 1000 yards), and never slackened their pace until the object of their attack was reached. Had the French not been

previously trained for a long time to double for long distances, and to execute at this pace the manœuvres of large bodies of men, not only would their actual losses have been greater by one-third at least, but it is exceedingly doubtful if they would have been able to carry many of the strong positions against which they were pitted.

Some of the statements made in this letter will doubtless be heard with surprise. That large bodies of troops should double from five to seven miles does indeed seem incredible. Perhaps it is not meant that they kept up the running pace throughout the whole distance, but merely that they moved at a rapid pace, alternately running and marching. It would have been satisfactory if the time in which the distances were performed had been stated, as this would have fixed the rate of movement with precision.

The following anecdote was related to me by Colonel Simmons, who heard it from an officer attached to the staff of the Emperor Louis Napoleon, an eye and ear witness of what he described:—

After some time had been spent in unsuccessful attempts to carry the village of Solferino, the Emperor, turning to an aid-de-camp, said, "Apportez moi la Garde." An instant afterwards, correcting himself, he said, "Non, pas la Garde, mais la Garde Voltigeur." La Garde Voltigeur arrived, was formed for the attack, and ascending a long steep hill at the double without a check carried the village of Solferino, the key of the Austrians' position.

This incident was mentioned to Colonel Simmons as a proof of the great coolness and self-possession of the Emperor, but it also serves to illustrate the manner in which the French troops employed in the Italian campaign made their attacks, and to confirm the statements reported by Major Adams.

Is there any regiment in the British Army which could at this moment move in the manner these French corps are reported to have moved?

Is there any regiment which after six months' proper systematic training might not be matched, both for speed and endurance, against the troops of the most warlike European nations?

Friday, May 30, 1862.

H.R.H. the Duke of CAMBRIDGE, K.G., General Commanding-in-Chief, in the Chair.

THE LINES OF LONDON: DEFENCES BY WORKS AND MANŒUVRE IN THE FIELD.

By Col. Adair, F.R.S., A.D.C. to the Queen.

Colonel Adair.—May it please your Royal Highness, Ladies, and Gentlemen,—It may possibly be within the recollection of many of those who have honoured me with their presence on this occasion, that this is not the first time on which I have been permitted to develop my ideas as to the defence of the metropolis. On the last occasion two elements of calculation were wanting, which have now materially, I may commence by saying, modified the principle on which I propose to construct the works which are detailed on this model. Those two elements are, the Use of Rifled Ordnance at Long Ranges, and the Establishment of the Volunteer Army.

Before I proceed I would, however, say, that I should not have ventured to treat a question of this great importance if it were not one submitted to public discussion now for many years in the most decisive and distinct manner by the proceedings of the Commission of Defence, inaugurated by order of Her Majesty's Government. When I find an inquiry made of one of the leading men of the great commercial interest of England, what the effect upon English credit would be if the capital were occupied by a foreign force, I have ventured to think it has become not simply a privilege, but a duty, on the part of any private subject of the Crown to discuss this subject, particularly when he has the opportunity and the advantage of having it submitted to the officers of the army who are here present. For, indeed, the fortification or the defence of London is not simply a representation of the defence of a frontier fortress, or even of a capital exposed by position to severe attack, as on the Continent; it represents the resolve of a great commercial people, that, while they have in no degree forsaken their attachment to the industrial efforts and the pursuits which make peace lovely, yet they are determined, so far as is consistent with human power, to protect that capital which is, as it were, the very heart of the English system. For that which affects the commerce of England, and its concentration in the metropolis, more or less directly affects the commerce of the world. The pulsation that proceeds from London extends a vibration through the remotest haunts of civilised man. Therefore, the object being of such im-

portance, and being, as I said, cast before the public for consideration by the proceedings of the British Government, I hold that it is our duty to bring the problem, if not to a solution, at least into the condition to receive a practical solution. And I am quite sure that on these grounds I shall meet with the indulgent consideration of those whom I have the honour to address.

In the first place, I object strongly to the proposition to dissociate the commercial and the military centres of England. I can quite understand—I admit most completely—that the Arsenal of Woolwich is a too precious possession, as a centre for the deposits of our military strength, to be needlessly exposed to attack; but, while we remove the means of reproduction of the materials of war from risk of sudden attack, there is, as it seems to me, no reason why we should divest Woolwich of its military character as a great depository of stores; still less, why, by abandoning Woolwich, we should subject London to be considered as an open town, to be the prey of the first assault. For it must be borne in mind that for many years the defenceless position of London has been an object of consideration elsewhere. Of that there is no doubt. We have heard it avowed openly; we have heard it hinted secretly; we know it to be a fact. Therefore it is, we must withdraw that perturbing element from the equation of our foreign policy. And this difficulty I found in endeavouring to work out the problem which I have attempted. I do not desire to stifle London, as it were, within lines of works which would prevent her free action, and materially change the character of the metropolis. But on investigating the disposition of the ground I find, as I have maintained heretofore, that London, under all the circumstances of its position, with reference to the genius of its people, considering also the rapid and converging communication which it possesses, is one of the most defensible capitals, if not the most defensible, in Europe. That I shall endeavour to make plain in the development of my idea during this lecture.

Now, with respect to the system to be adopted. On the first occasion of which I spoke, the two great elements of defence, to which I now attach great importance, were absent, and my idea was to provide forts mainly on the bastion system, and therefore of small capacity, and subsequently to construct continuous lines. The positions which I then occupied are much the same as those I propose to occupy as the internal, or alternative, line of defence on the present model. But I have been obliged to go far beyond that zone of defence, and for this reason: In the first place, the bastion system is intricate and complicated; it requires a large proportion of scientific outwork, and it gives very small spaces for the masses it may have to receive in the last result. For that reason I abandon the idea of the bastion system. Again, viewing the conditions under which artillery fire is now projected, and that the chief danger of the metropolis lies in the risk of conflagration, it appeared to me imperative to remove the zone of bombardment as far as possible from the dangerous point of conflagration in the city. It was then necessary to select a system of an appropriate type. I found in the plastic character of the polygonal system, as adopted generally in Germany, and which has now been applied to a considerable extent in this country also, the resources which I required.

But, in passing from the bastion system to the polygonal, there was another element of calculation to be weighed. It is certain that the power of projection has always been the unit of calculation in defensive war. The walls of Aurelian have their towers, as may be seen at this day at Rome, just distant from each other what the double "jactus pili"—the heavy javelin of the Roman soldier—could cover. The same principle which prevailed in the walls of Aurelian, passing over the calculations of M. Vauban, has been adopted by English engineers, as may now be seen in the lines of Stoke's Bay, where 600 yards is substituted for the 360 yards of M. Vauban. Consequently, I adopted 600 yards, trusting to the range of the English rifle as the unit in defensive lines for the maximum of calculation in the line of defence, and also of armament of the works when constructed.

With regard to the construction, having prepared the trace on the principle which I stated, I found that it was abundantly necessary that these continuous lines should be supported throughout by works capable of a substantive defence. Again, in reliance on the simplicity of the polygonal system, and trusting to the heavy mass of fire by which the defence of such a capital must be supported, I am contented with very few advanced works. The ravelins that are attached to the Prussian and the German system, the caponiers which are intended to give a flanking defence, are all that I have adopted. In fact, I have endeavoured, by heavy masses of earth, such as shell fire shall be almost powerless to disturb, by a ditch of unusual capacity and depth, by the concentration of the fire of rifled ordnance on all points that are subject to attack, to compensate for that more intricate and expensive system which Vauban originated, or at all events developed in its completeness.

With regard to the arrangements of the works for the defence of London, I find London, for the purpose of defence, commencing from Woolwich, and passing round its complete exterior, to be an octagon, of which the sides amount to 55 miles 944 yards. I break up this octagon into lines of manœuvre, for I am not content to retain the troops that should be sufficient for the defence of London ingloriously behind their continuous works; and I consequently adopt the sides of the polygon as lines of manœuvre on which troops may move, supported by the fire of artillery in position. From Eltham to Anerley one line of manœuvre would extend; from Anerley to Kingston a second; from Kingston to Twickenham a third; from Twickenham to Hanwell the fourth; from Hanwell to Harrow the fifth; from Harrow to Hendon the sixth; from Hendon to Stamford Hill the seventh; and the eighth from Stamford Hill through the marshes of the river Lea to East Ham. These lines would form the eight fronts of the polygon, and the eight lines of manœuvre. With regard to Woolwich, I am aware of a difficulty in the defence of the Arsenal from risk of fire therein; yet it would seem exaggerated, for this reason:—In the first place, there is a broad screen of hill interposed between a large proportion of the Arsenal buildings and the possible emplacement of powerful batteries; between that large surface of workshop, factory, and storehouses, which might by their conflagration impede the defence, we have the obstructive power of works, armed with heavy ordnance, extended along the eastern slopes of the hill,

and we have the means of projecting preponderating masses of mortar-fire from the crest. But Woolwich, as it does not afford space for manœuvre in the field, and for the considerations I have mentioned, must rely on its substantive strength as a fortress. I propose to connect the upper and lower lines of batteries of Woolwich with the rolling ground on the south-east; to place casemated batteries on the slope of the hills, and mortar batteries to search the hollows of ground which afford cover to troops in formation, and approaches to sunken batteries of bombardment.

I propose a polygonal fort to defend the rear of Shooter's Hill, and to throw an auxiliary fire athwart the Thames, and aid in the defence of the lines in the Essex Marshes. The guns of this fort will also sweep that portion of the long line of valley which passes across the high road, and so, leaving Eltham to the left, is traced by Mottingham Hill, on the western slope, to a redoubt which lies north of Beckenham. Woolwich, as regards its garrison, would be held by a portion of the regular army. I calculate the armament on a special scale, as follows. In consequence of the adoption of the polygonal system and a new unit of calculation, it became necessary to establish what I will call equivalent fronts of construction and of defence. I interpret the equivalent front of construction to be the 600 yards of the polygonal system, compared with 360 yards of the bastion system, and, if so, it is also the equivalent front of armament. Now there exists a scale which has been tested on many occasions in the defence of regular works, which allots to a front of fortification 11 guns, 6 mortars, and 2 field guns = 19 guns. Now this proportion was calculated on the special service at particular stages of the siege, against enfilading and breaching batteries, against lodgments, and the like incidents. But, on the principle which reduces the siege-operation to one simple event, I preferred to select a single calibre of gun, the 40-pounder Armstrong; and I tested the value of the 40-pounder Armstrong, against the aggregate power of these guns, under the novel qualities of increased range, heavier metal, and rapid fire. The result was this, that, excluding mortars and field guns, for which I provide elsewhere, in the question of the preponderance of force compounded of range, momentum, and frequency of impact, I can, with eight 40-pounder Armstrongs, throw more effective weight of metal than with the 11 guns which are allotted on the original war scale, regard being always had to the increased range and rapidity of loading, which last, however, I do not estimate very highly. This brings me practically to one 40-pounder Armstrong for every 75 yards. Now, the principles of defence which I am describing do not so much express operations of siege-resistance, except in their application to the forts and redoubts, as to field fire in disturbance of the enemy's formations. I attach much greater value to accuracy and distinctness of fire, than to excessive rapidity, which produces a salvo, but not the crushing effect of concentrated fire.

I now come to the arrangements which I propose for the lines. I have endeavoured, as far as possible, to avoid the greatest danger on these long lines, that of enfilade. I have, therefore, so planned the trace that either the prolongation should fall on inaccessible ground, which would rarely happen in this country, or on ground on which the defence can accumulate a larger weight of metal than an enemy could project. For instance,

it appeared doubtful whether Eltham should be occupied, but I preferred trusting to the mass of fire which could be delivered from the south-west angle of the lines on the Woolwich system to occupying the plateau. But there is another point with regard to the use of these forts and redoubts. I propose, in the first place, lines of manœuvre external to the continuous lines; if a reverse should occur there is a means of defence by the continuous lines; or if any portion be pierced, and the flank turned, and the parapet reversed, two means of defence remain in reserve; the flank and rear fire of the works and redoubts will sweep these lines in reverse; and, secondly, they will serve as *points d'appui*, or standing flanks, whereon to renew the engagement, which may have had an unfortunate event on the ground exterior to the lines.

The command given to the works over the country is twenty-two feet. It will be observed that the minuter details have been suppressed entirely, in order not to complicate the plans; I have not given the traverses, the flèches that cover the passages through the lines, or the magazines. I have simply indicated the position and the form of the proposed works.

The first line of battle having been traced from Eltham to Anerley, the troops are disposed in nineteen battalions of infantry in advance of the works. The strength of the garrison is assumed on the ordinary calculation of two men to each yard of musketry parapet. This gives 180,000 infantry, and in comparing my calculation with that which has generally obtained, especially in the French service, I find a very satisfactory agreement. For instance, taking 180,000 men for the infantry that London is bound to supply—and in my judgment, if this metropolis cannot supply of its own citizens 180,000 men for its defence, the defence of London must be desperate indeed; 21,920 artillerymen for the 2,192 guns, with which I propose to arm the works; and 4,500 cavalry in the ordinary proportion, I get an entire garrison of 206,420 men.* Calculating on equivalent fronts on the principle of Cormontaigne, as approved by Carnot, on the principle of Lesage and of Noizet, and of the Commission of Defence of the present French Government, I find that for the hexagon, which coincides to a considerable extent in essentials to the proportions of my lines, the estimate varies from 199,800 to 228,000 men against 206,420.

I then proceed from the Anerley redoubt, by Mitcham, in front of Coombe, to Surbiton, on the South Western Railway. This portion of the line requires very considerable care in its defence. Few accidents of the ground lend themselves very satisfactorily to the defence, but redoubts have been placed in such positions as may give standing flanks from manœuvring distance to distance, and the infantry of manœuvre is interposed at the points mentioned, with the power of moving up reserves from the interior on occasion. The practical result of such works will be shewn hereafter.

A disadvantage of long and continuous lines is in moving infantry from within the enceinte in order of battle. Some excellent remarks on this subject were published by Sir William Reid in the Professional Papers, R.E., from which I derived considerable information. I therefore determined to ascertain whether I could not, in default of a covert-

* Lt.-Col. Kennedy's calculation gives 122,375, being 4-20ths of males capable of bearing arms within these lines.—*Journal R. U. S. I.* vol. iv. p. 60.

way, which would have given external *places d'armes*, prepare *places d'armes* within the lines, which should at the same time give facility for filing out battalions in order of battle. The exterior side = 600 yards, dropping a perpendicular of $\frac{1}{12}$, and taking $\frac{1}{3}$ of the exterior side as a line of defence, at the point of the perpendicular, and at the distance of the shoulder angle, I trace an arc of which the chords form the interior sides of the *place d'armes*. The result I have established is, that the battalions, being formed in rear of the line, file through a postern gate, in the re-entering angle, into this *place d'armes*, and remain, if necessary, in columns of companies, since the width of the ditch will enable any movement to be made in such formations as may seem expedient. Again, if the line of defence be traced to the point where it falls on the shoulder angle, it will be observed that the troops in column are perfectly secure from any bounding shot, or from any but vertical fire.

I proceed to explain the armament with which I propose to defend the shoulder angles. I set off thirty yards on either face, which is to admit of construction in concrete for the establishment, in the first place, of embrasures on three lines of fire perpendicular to the parapet. It is essential that the fire should be perpendicular to the parapet when a defence must be conducted, to a great extent, with troops who may not yet have had a thorough training, which makes it necessary to deliver fire on a perpendicular to these three embrasures. At the point of convergence of these lines, I place a turntable, designed to facilitate the entry into its proper embrasure of a 40-pounder Armstrong gun on a garrison carriage. The simpler the arrangements the better; and if the Armstrong gun be kept on the permanent, and not on dwarf, platforms, it may be used at once at any point to which it may be transferred, for, although the possibility of a general assault on London is assumed, still no soldier will believe that such general assault is probable; and therefore any gun may be withdrawn for reinforcement of an adjacent battery when not required for service. The result then is, that I obtain the means to fire under cover through an angle of 135 degrees; these guns sweep the country, and after a certain point they sweep the ditches. But, in order to secure the perfect command of the ditches, at the base of the scarp of the shoulder angle is placed a small battery of carronades on garrison carriages of wood, which I prefer as simple guns to any others for sweeping the ditches. The first attempt in an attack upon the lines by scientific means would be to attach the miner to the shoulder angle; therefore it is imperative that no sap should cross the ditch with impunity. There is, of course, from the very great thickness of the parapet, dead ground at the foot of the scarp, which will require to be swept by musketry, and a small loop-hole gallery is built in the re-entering angles for that purpose. Then, filing the battalions through the ramparts of equal breadth with the ditch into the country, they pass a traverse, designed to cover the ditch at the salient from direct fire. This mass is left in the counterscarp at the junction of its salient, and the prolongation coincides with the superior slope of the parapet; consequently musketry from the salient of the rampart can see to the foot of the traverse.

For the defence of these lines 30 battalions are allotted, and in the event of check, the lines being forced or turned, in the re-entering

angle contained within the Ridgeway at Wimbledon, and the high ground of Tooting and Streatham, I find a space within which the assaulting forces would operate with disadvantage. For an interior line of operations is useful so long as it can be maintained, in order to establish unequal distances between exterior lines, but so soon as the troops moving on exterior lines include the manœuvring force, being equidistant from each body, especially if confined within a right angle, then the assaulting force, being as one to two, must suffer loss on all ordinary calculations.

Passing then to Surbiton, which lies on the south-western slope of Kingston Hill, it appeared impracticable to include it with any satisfactory engineering results within the lines; consequently a redoubt is placed on the crest of Surbiton Hill, which gives its fire in reverse, to protect this angle. The work towards Kingston Hill also combines with artillery lines on the descending slope to the westward in throwing a flanking fire over Kingston, and on the flank of Kingston Bridge head, near Hampton Court.

I now come to the combination of lines of passive defence, so to speak, and of manœuvre. For reasons which I have published, my impression has been that the weight of attack in an invasion will inevitably follow the course of the Thames. In a former plan, published in 1860, I have shown the route which army corps must presumably follow, and in all these cases I have accommodated the theory to the face of the ground, as causing a certain line of march to be adopted. Assuming then that the weight of attack falls especially on the south-western side, it will be favourable to manœuvre, and manœuvre is precisely the quality in which an invading army will presume that it excels the national forces. Easy access across the river, and an easy mode of returning, if necessary, must then be provided. At the various points indicated I have prepared bridge-heads, which are traced on the sides of a triangle, whose base is coincident with the long axis of the main stream. The sides being determined, the flanks are drawn as a matter of course. Crossing the river at Kingston, at Teddington, at Twickenham, and at Richmond, I have formed these bridge-heads. Now, a very remarkable assumption has been brought under my notice, namely, that Teddington Locks control the lower Thames; that is to say, if Teddington Locks and Weir were broken down, and the river swept clear of those constructions, the river above would become fordable; and that, if the locks were then simultaneously opened, the first tide would rush to the sea with a violence that would affect the shipping in the river, and that, if they were then closed, no subsequent tide would hold up a sufficient accumulation of water, and the metropolis would be thus deprived of one means of obtaining a supply. I have accordingly protected Teddington Locks with a sufficient bridge-head. For the line from Kingston Bridge head to Twickenham Bridge twelve battalions are allotted. I might take occasion here to say that an advantage which would immediately result from taking lines of such an extended sweep is, that the value of land becomes inconsiderable; and that there are very few points where I have interfered with property, because I hold that the defence of London must be popular and national, as well as scientific, and that we are bound, therefore, to consult individual convenience, so far as it is consistent with

public duty; for the nation would rather pay more largely for the construction of these works, and more readily equip troops for their defence, if it knew that the cottages of the humble were respected no less than the dwellings of the wealthy in the arrangements made in defensive details. I may here mention this, because the point at which I have most sinned against my own canon is at Isleworth. Being unwilling to project the lines too far into the plain, I have taken in Isleworth Redoubt a small amount of property. This is flat ground. I supplement the want of a great body of infantry on the spot by a cross-fire of artillery. Passing thence the defensive line of the Thames level, as continued to Boston, and completed to Hanwell, at the viaducts on the Great Western railway, this system of defence rests on the valley of the Brent. From Twickenham Bridge head to Hanwell 14 battalions are distributed.

It is to be remarked that a very large proportion of the lines of London is susceptible of defence by inundation. For instance, the whole valley of the Lea, and of the Brent, a large proportion of the ground where the stream enters Richmond Park, the line of the Wandle, of the Ravensbourne River, and of the low ground beneath the prolongation of the Ridgeway—all these points are capable of affording a large defence by inundation. For this peculiar advantage is incident to the defence, that the outfalls of the streams lying within the lines are completely under control, and the dams and sluice-gates cannot be destroyed by the fire of field artillery. Crossing the valley of the Brent, I arrive at Horsington Hill, a most remarkable position, which dominates the lines and intrenched works on the north-west slope of Castlebar Hill. This hill is not generally known to the inhabitants of London. It is not visible from the Harrow Road, and, except to those who stand on the crest of Castlebar Hill, is not visible from the southward. It rises steep from the flat meadows of Perivale, with an easy slope from the north. As a point of observation and reinforcement, it is of very great value. I have consequently traced artillery lines, and constructed mortar batteries and casemates on its exterior faces. The proportion of infantry from Hanwell to Horsington Hill is 12 battalions.

Then came the question of Harrow. Harrow projects a narrow plateau of considerable emergence, and, therefore, of difficult treatment, into the north-west. Still, Harrow must not be abandoned. I felt this also, that, as one of the great centres of our system of education, it should be respected in its entirety, and preserved, as it were, inviolate from engineering operations. I am confident that those who have an interest in our great public schools will appreciate this forbearance. But the ground is very difficult. It is divided into ridges, which afford points for the formation of troops, without giving any very great facility for projecting works of defence. Consequently the Harrow lines are reinforced by a system of cavaliers, which the continuous ascent facilitates. But at the salient this question arose. A work of a very peculiar kind was required, which would give flanking fire, reverse fire, and also sweep the approaches, a very large work, and yet not liable to the destructive effect of vertical fire concentrated on an equilateral parallelogram. But in the Professional Papers (vol. ix.) by which the Royal Engineers have enriched our scientific knowledge, I found a plan prepared

by Colonel Bainbrigge, R.E., to which I am indebted for the trace of that redoubt. It is a redoubt of peculiar efficiency, and was originally designed by him in connection with the defence of a continuous enceinte, and is defensible by a garrison of from 100 to 200 men. From Horsington Hill to Bainbrigge Redoubt eighteen battalions are assigned to the defence. From Harrow the next line of battle passes to Hendon, and is maintained by thirteen battalions. At a distance of 1 $\frac{1}{8}$ mile S.S.E. rises Woodcote Hill, on which is constructed a polygonal fort, and on the right rear Barnes Hill uplifts slopes on which works may be constructed to combine direct fire with Woodcote Hill, and also to sweep in reverse the lines which connect Harrow with Hendon. On the right front, on the left of the Edgware Road, The Hyde, at an elevation of 289 feet, dominates the country in advance, as an armed salient to the Harrow and Hendon districts. At Hendon a polygonal fort has been constructed according to the natural distribution of the faces. These works cover also the Brent reservoirs, it being of exceeding importance to maintain the command of the water, both fluvial and in reservoir, which is to supply our metropolis. From Hendon the line then passes to Muswell Hill, requiring thirteen battalions. A redoubt on Clatterhouse Green to the S.S.E. maintains, in connection with a smaller one on Golders Green, continuous fire to Child's Hill. Supposing it to be a direct assault against this re-entering angle of the lines, a redoubt constructed on the Finchley road above the cemetery directs its fire against flank and rear of an attacking force, and searches the hollows. From thence the line passes to Muswell Hill, of which the northern slope is of considerable steepness, and therefore must be defended by musketry fire rather than by direct artillery fire. On the crest of the hill it became necessary to construct a work which would give fire from four fronts, and also prevent the occupation of the eastern spur of the hill. Now, on Muswell Hill I found that the ground is of that treacherous and uncertain quality that, except at enormous expense, it would not have been possible to raise any work suitable to the position. On the crest, or rather at the *col* or neck of the hill, close to the church, a work is constructed which gives a fourfold front of fire; one sweeping the sloping ground to the northward, another giving its fire to the front of Highgate Hill and Child's Hill, another looking into the low ground about Hornsey and Crouch End, and another accumulating such a front of fire on Muswell Hill as would render it impracticable to construct works either of siege or of permanent investment. Then descending the Great Northern line, and passing by the New River to Stamford Hill, there is a redoubt on Crouch End, and artillery lines secure the plain below in the direction of Tottenham. For manœuvring twenty-eight battalions are detailed, with a reserve of twelve. The last line of manœuvre commences in the valley of the Lea, and demands the services of twenty-seven battalions.

The difficulty of establishing works in the valley of the Lea arose not from the risk of inundation, but of interference with property on the south-east portion of the lines, and from the danger of bringing the works under the control of the slopes to the eastward. I had at one time proposed to establish a system on the principle of Cohorn; but the usual objection to the employment of the bastion system, namely, intricacy of trace, and confined space, prevailed. The intricacy was found to be so

great in a level interrupted by frequent water-channels, that I was obliged to abandon it, and I have substituted artillery lines, closed at the gorge, as redoubts, and resting on the right flank on the great redoubt at Plaistow, and on a polygonal fort at East Ham. The lines are observed by a heavy work on the plateau of Clapton, a heavy work near Victoria Park, and a smaller one on a rising ground at Bromley Marsh. The general infantry reserves are fifty-nine battalions, distributed on the railway junctions.

Such are the trace, the distribution, and the components of the first line of works. I will now proceed to develope the interior line. As I have stated, the first line of defence is composed of troops manœuvring in the field, with the support of batteries and heavy works. They have the alternative of manœuvring in the field, and falling back, and forming on these works as standing flanks. The map will show what my proposition would be in the event of these lines being forced, and the heavier works left to maintain a substantive defence. It will be remarked, that on the model nine points are indicated by engineering cairns. These represent the positions between which the intervals would be available for defence by infantry and field guns. The works have not been introduced in plan to avoid complexity, but can be readily supplied by the experience of any officer, and are shown in the map of manœuvre by circles. I have assumed the same proportion of battalion front for the defence of the interior lines as on the exterior. The reason of that, as will be seen, is, that I wanted to test precisely the relation in tactical equation between a combination of troops supported by standing flanks and batteries, and of such as have limited points of support from forts while manœuvring on a smaller surface. The inner line of defence bears to the outer line of defence, the proportion of 5 to 8. The number of forts is the same; but on the exterior line 34 redoubts and 6 bridge heads give support to the troops in line of battle. And it will be observed that the external line of battle is formed with supports and reserves, but that there are not troops enough for such disposition on the interior line. Now, that fact is very important. Every postulate should be reduced to a mathematical expression, and thus it is shown, that, whereas the interior line of defence is 35 miles, while the line of exterior defence is 59 miles, yet the battalions formed on the shorter line are not brought into such close contiguity, are not in such an available line of battle, as those disseminated over a larger surface, being supported by standing flanks and batteries. From which I would draw this conclusion, that the value of a line of battle formed on works capable of substantive defence, and supported by redoubts and batteries, is to an equivalent line of battle formed on works alone as 8 to 5, the advantage being nearly one half to the line of manœuvre consolidated by occasional works and artillery lines, and consequently by field-works and batteries of position.

With regard to internal arrangements, the facilities that the railway system gives for maintaining communication must not be overlooked. At the convergence of these lines are points at which the reserves are placed *à cheval*, from which they can be directed on any line of battle. Taking the lines westward, and southward, and north-west of London, every division has a reserve within a quarter of an hour of the line of battle. The greatest distance is about six miles. If I be correct in that estimate, the railways multiply the power of reserve, as compared with the ordinary marching

of troops, to a point ranging from 8 to 16: that is to say, 20,000 men in reserve on a railway would be raised to some numerical expression varying from 8 to 16 times in their arrival on the field, and therefore in defensive momentum. But if a railway prepares, accelerates, and assists the decisive strokes of battle, on the other hand it multiplies the losses of the defeated force. In the defence of a country in which there is no railway, the retreat is a withdrawing from the front; but on a railway it is a congestion of forces. The victorious army would act with largely increased power on a force retreating on the narrow line of a railway, which would necessarily be without a knowledge of lateral communications to relieve the crowded columns of route. This is an inconvenience to be guarded against. If masses of troops be projected by a railway on a field of battle, their subsequent retreat should be prepared more carefully than if they retreated by parallel columns across the country.

Now, having explained these views so far, there are some points which I cannot permit myself to pass over, as touching the position of London itself. I have said we all feel that the defence of London must be national and popular, as well as scientific. It is not the mere defence of a fortress, nor is it a defence that can be permitted to be unsuccessful. More lies on the defence of the metropolis of England than the mere abatement of any power and influence that belongs to the sceptre of the sovereign beyond the seas. I dissent entirely from the opinion, that, if London were captured, on that ground national resistance should be abandoned. By no means. But the blow would be a severe one, and a blow that would require no ordinary fortitude in the country to meet. There are disturbing influences of a social character which are anticipated in the case of such an event as an attack on London. In the first place a real and very serious one is that of conflagration. I know that conflagration may be rendered harmless, or, at all events, detained in quarters of the capital where its ravages would be of comparatively small importance. Previous to my last lecture on the defence of London I had some conversation with that brave man Mr. Braidwood, who lost his life, as he had passed it, in the service of humanity. He pointed out in minute detail the certain results of bombardment in the city and commercial depôts. He pointed out warehouse after warehouse filled with the magnificent products of our industry, and from his experience he made it evident that the chief enemy of London is conflagration. Yet with subdivision of labour, by care and with forethought, even this terrible monster may be bridled. On the map crosses are placed to indicate the volunteer forces mustered at the selected alarm posts. At each alarm post I propose to establish a fire brigade to act within a special district. And there is this remarkable circumstance,—the power of fire, as the late Mr. Braidwood explained it, extends its active force to but a trifling distance; embers may be carried any distance by the wind, but sheets of flame do not pass beyond eighty feet. Practically one side of the New Road may be in flames without communicating to the opposite buildings.

Then there is another point with regard to the condition of the inhabitants of the metropolis in any quarter, if invested. The real difficulty in English defensive warfare would be to withdraw the non-combatants, and to supply them with food. It is said it would be utterly impossible to feed

London, which is an assumption to be considered in combination with the safe conduct of the non-combatant. Supposing that London were invested and assaulted on whichever side might be selected, it surely could be no difficulty, with the communications spreading in every direction, with the means of organisation and power to move troops by railway, to remove from the front of attack the whole of the non-combatants. It is nothing new. During the threatened invasion of Napoleon every Lord Lieutenant of maritime counties had distinct instructions as to the removal of non-combatants, food, and stores of all kinds to the interior. If that could be done then, with the insufficient aid of only animal traction, it ought to be more easily effected now with the facilities which railways afford. Pass the non-combatants to the rear, but not as a helpless crowd. Select beforehand the points on which these thousands are to be directed, and there prepare the magazines from which they are to be maintained, until with the retreat of the invading army returns the power of re-occupying their homes.

Then the social disorganisation which waits all such terrible convulsions has been urged as an apology for surrendering the capital. A strong picquet would be under arms at each alarm post; and I do not think it would be difficult for the metropolitan police, supported by strong picquets, to crush any attempt of the dangerous classes to create disturbances. This is not a point on which we need dwell for a moment in apprehension.

Now with regard to the cost: I find my estimate has not met with general concurrence, it being conceived that the land will be much dearer. But in the first place I take the large quantity of 15,000 acres. Those 15,000 acres are not of the valuable land on which the villas which these lines are designed to guard are constructed. The land is generally valuable alone for pasture, and that not of a very high quality. I am aware that some land would be valued at £700 an acre, but I believe the land purchaseable at and less than £100 an acre is so greatly in excess of the more valuable ground that £100 an acre would be the average price. Then it is said the Government always pays largely; now, I know no reason why Government should pay more than an individual. I am confident, if the point were judicially put to juries impanelled to assess the value of land, that they would give an equitable award in accordance with their duty and the fact. Again, it is said that the railways have to pay largely. Now the railways make the ground valuable, but military lines leave the condition of the country unaltered. But in any case I believe the maximum estimate which is given in the report of the Defence Commission, of £179 11*s.* 4*d.* per acre for works, is a far larger sum than would be required for the ground on which the proposed line would be placed.

And so, with your permission and the kindness of those who have heard me, I have briefly given the reasons that have induced me to propose this mode of tactics. I have felt that I was, to a certain extent, perhaps to a great extent, presuming on what might be the province of abler hands, but I felt that, when an English question is submitted, every Englishman is entitled to speak.

I have attached great importance to the power of resistance—direct resistance—afforded by the masses of Volunteers. The Volunteer army of

London at this moment numbers, I believe, 20,000 men. Now, I do not at present regret the comparatively small numbers of the Volunteer force, compared with what might be expected from a large population, because there is a consequent opportunity of more accurate drill. In the 20,000 Volunteers, I see the future officers and non-commissioned officers of the Volunteer army of London. 20,000 properly trained men can soon train 180,000 men if required. And that they would thus labour cannot be doubted. They would feel that their honour was engaged in bringing the force to the highest point of efficiency. Their willingness and devotion to the public service have already received an enthusiastic acknowledgment from their countrymen, which many a bold soldier of the ridge of Delhi and of the trenches of the Crimea would have thought an adequate recompense for all his trials. Therefore, I know what exertions that great body will make. Within the capital lie the means of giving strength and volume to that power. There was a time when London was threatened. Two hundred years have passed away. It was a time of apprehension, and strait, and doubt, especially to the City, which then formed London. For the forces of the King were on the march, and within and around its walls was concentrated the power of the Parliament. The men of London did not hesitate. They threw up entrenchments in Hyde Park, of which the traces may, it is said, be found to this day. They armed in defence of their rights, and abided the shock. As they did then, so would London now.

I have to thank your Royal Highness for the attention with which you have honoured me, and I have to thank those who have heard me. I now leave in their hands the decision of the question, whether or no I am justified in the assertion which I repeat, and which knowledge day by day only confirms, that, considering the circumstances of ground, the organisation of our people, and their spirit of defence, " London is the most defensible capital in Europe."

H. R. H. the Duke of CAMBRIDGE: Ladies and Gentlemen, I am sure you will authorise me in saying a few words in reference to what has fallen from my gallant friend who has just addressed you. It would be impertinent in me if I were to follow him in any of the details into which he has gone in that plan. And not only would it be impertinent, but I think it would be improper in my position, if I were to attempt to offer any opinion which I may have formed so hastily upon what has fallen from him. But I am convinced that you will all agree with me, and you will authorise me to state to him, that we have been much gratified with the interesting and clear statement which he has made of his views as regards this great and important question, a question which requires immense study. It is clear the greatest care and attention have been given in the remarks which have just been offered to us. I, therefore, hope that my gallant friend will forgive me if I do not commit myself in any respect as regards what has now been said: but at the same time he will receive from me the acknowledgment of this company and my own, for the very interesting and valuable lecture which he has given to us, and which I have no doubt many of us will think over for a long time to come in all its various minute and important details.

APPENDIX.

ON THE POLYGONAL SYSTEM.

The most recent works on the polygonal system are those of General Prevost de Vernois, of General Noizet in reply, and of M. Ratheau. Colonel Humfrey has published a valuable treatise on the polygonal system as exemplified at Coblentz.

Ratheau examines the original system of Montalembert, as discussed by Zastrow, Blesson, and Müller, in opposition to Maurice de Sellon and Mangin.

His work (Etudes sur la Fortification Polygonale) is elaborate and instructive.

His design is to show that on works of high finish the polygonal trace is more expensive than the bastioned, but that the defensive power is greatly augmented.

He calculates the space covered by works of construction as nearly equal in a polygonal hexagon of 500 yards, and a bastioned decagon of 360 yards.

But it is admitted, that for the defence of large cities the trace of Cherbourg by Montalembert, slightly modified, is superior to the bastioned trace, if each is furnished with wet ditches. For Ratheau considers the polygonal system loses when the ditches are dry; to compensate which the caponier should join the curtain.

But, on a careful review of the entire argument, I adhere to the polygonal system as proposed for London: on account of the simplicity of the trace, cheapness in works of low finish, perpendicularity of fire, convenience for massing troops, and facility of defence by sortie.

GENERAL REMARKS.

The model * shows the defensive capabilities of London by forts, redoubts, and continuous lines, on an area of 20 × 14 miles.

The octagon of defence, = 55 miles 944 yards, is traced on lines drawn through Woolwich to Eltham, E.S.E.; Anerley, S.E.; Kingston, S.; Hanwell, W.; Harrow, N.W.; Muswell Hill, N.; Stamford Hill, N.E.; East Ham, E.

Each face of this polygon represents a line of battle, of which the works at the angles give standing flanks and the intermediate works supports.

Nine points for forts on an inner line of defence are indicated on Tele-

* The model referred to was afterwards placed in the International Exhibition of 1862. —Ed.

graph Hill, Forest Hill, Tooting Common, the Ridgeway, in Richmond Park, near Mortlake, near Ealing, on Hanger Hill, and at Whembley, by engineer cairns, = 35 miles, 586 yards, in combination with the N. and E. portions of the exterior sides.

The scale is of six inches to the mile, with vertical augmentation by six to give appreciable relief. But it may be doubted whether the angle of exaggeration does not coincide with the angle of perspective. The ground slopes outwards, at a favourable angle for manœuvre and artillery fire. Sixty-two roads permit the sorties, which an interior railway system facilitates; and streams supply means of inundation, as in the marshes of the Lea and of the Brent.

The forts and permanent works are on the German trace, as best adapted to defence by direct fire, and by sorties from superior capacity.

For it is assumed that the fire of breech-loading ordnance and of volunteer infantry will supply the principal defensive power; wherefore, in order to obtain effective fire, no re-entering angle, or angle of defence, should be less than a right angle.

It is also desirable that the works should be of a simple trace, but formidable, from a wide front of fire. The zone of fire extends to 2,500 yards, giving an elevation of 6°, hence a depressed arch to casemate.

The forts are adapted to prolonged resistance; the redoubts secured from insult; the lines completely swept by flanking fire; and observed, in reverse, by the permanent works.

Arcs of assault to include the external lines of battle are drawn from four centres, or reserve stations: Wormwood-Scrubs, Islington Cattle Market, Peckham New Town, and New Wandsworth.

The slopes of the country are followed, so as to give low angles of depression from ramparts secured from enfilade. The covert way is suppressed, and the glacis slopes from perpendicular counterscarp.

The unit of calculation for construction and armament = 600 yards.

The forts and large redoubts are constructed in brick.

The lines are in earth, with a scarp in concrete; the main ditch, 30 yards wide by 30 feet in depth, has a cunette, and wide ramps for sortie. Mortar batteries are constructed with parados. The lowest command = 22 feet.

The casemated batteries are recessed, so that a rolling projectile would clear in descent the angle included between the terre-plein and the face of the casemate.

The flanks of the bridge-heads on the W. front are traced on sides of a triangle, whose base coincides with the mid-stream line.

The armament is calculated on the regulated war scale, less the difference between the mean service ranges of rifled and smooth-bored guns, multiplied into the relative rapidity of fire from breech-loading and muzzle-loading ordnance. This difference, on equivalent fronts, equals a deduction of $\frac{5}{16}$ from the received proportion.

All guns on ramparts are mounted on garrison carriages, in Haxo casemates, turned in concrete, and stepped in the splay.

Each casemated flank to be supplied with a turn-table, and built on a modification of the Haxo casemate, allowing the gun to traverse through

135°. Lead concrete to be used against injury from cone of blast. Iron gabions for revetment of embrasure.

The fire of casemated flanks grazes the line of defence, the ditch being swept by carronades, with a drop in front.

The re-entering angles in the bastioned lines form *places d'armes* for sortie, under cover of the shoulder angle.

Volunteer alarm-posts, stations for fire-brigades, and police picquets, are marked by crosses.

The lines having been carefully traced in advance of towns and villages, the amount of house property to be purchased is small.

Value is governed by facility of access rather than by distance. 100 yards are allowed in depth for works, and 300 yards additional for a military zone, on which few buildings now exist, and none could hereafter be constructed.

CONSTRUCTION.

Districts.		Length of Faces.	Lines of Manœuvre.	Lines of Artillery.	Lines of Musketry.	Forts.	Redoubts.	Bridge-heads.	Battalions.
		Miles.	Miles.	Yards.	Yards.				
E.S.E.	Woolwich—Eltham	4·29·1	.. ..	13,500	.. ..	1	..	..	..
S.E.	Eltham—Anerley	6·783·2	6·938	7,600	11,900	2	4	..	19
S.	Anerley—Kingston	11·1012·0	11·1012	2,500	13,900	1	8	..	30
W.	Kingston—Hanwell	8·234·2	8·352	6,950	10,000	..	2	6	26
N.W.	Hanwell—Harrow	5·293·1	5·537	2,050	10,800	1	3	..	30
N.	Harrow—Muswell Hill	8·1466·2	8·1466·2	800	23,600	3	8	..	13
N.E.	Muswell Hill — Stamford Hill	3·601·1	3·601·1	3,000	9,000	..	2	..	21
E.	Stamford Hill—E. Ham	7·1642·2	7·1642·2	300	10,400	1	7	..	27
		55·944·2	51·1269·2	23,200	89,600	9	34	6	225

TOTAL.

Forts	9	
Redoubts	34	
Bridge-heads	6	
	—	49
Casemate Batteries	9	
Mortar „	23	

EQUIVALENT FRONTS.

Works	107	
Artillery Lines	50	
	—	157

(Excluding Woolwich.)

COST. (Approximate.)

Land.	Acres.		£
Forts . . .	1,090		
Works . . .	4,935		
Lines . . .	8,896		
	——	14,921	1,492,100

Construction.	£	
Forts . .	450,000	
Works . .	893,875	
C. and M. Batt.	67,000	
Lines Art. .	249,750	
Musketry .	623,200	
	—— . .	2,283,825
Guns, 1842 (excluding Carronades) .		368,400
		4,144,325

ENCEINTE OF PARIS. (Approximate.)

	£	£
Bastioned Fronts . .	$94 \times 32{,}000 =$	3,000,000

WORKS.

			£	£
First Line . .	25			
Second . .	24			
Third . .	5			
	—	$54 \times 60{,}000 =$		3,240,000
				6,240,000

(The purchase of land not included.)

ARMAMENT—GUNS IN POSITION.

	Forts.	Re-doubts.	Bridge-heads.	Artily. Lines.	Flanks.	Carron-ades.	Case-mates.	Mor-tars.	Total.
E.S.E.	48	..	..	194	..	..	41	48	338
S.E.	72	78	..	96	40	98	..	16	400
S.	20	100	..	34	48	40	..	30	272
W.	..	35	92	92	14	..	..	..	233
N.W.	12	26	..	18	67	69	24	12	228
N.	89	93	..	17	80	35	..	18	332
N.E.	..	15	..	34	32	32	..	24	137
E.	40	92	..	4	40	36	..	..	212
									2152
								For Redoubts	40
									2192

ARMAMENT OF BALAKLAVA LINES, FEBRUARY, 1855.

Length of lines—yards		4,500	
Armament—Guns		17	
Howitzers		20	
		—	37

1 gun per 121 yards.

Gunners R.A.	125		
M.A.	50		
	—	175	

Garrison. English	2,420		
French	450		
Turkish	1,310		
	——	4,180	

One troop of Horse Artillery.

Evening Meeting.

Wednesday, April 30th, 1862.

Major-General the Hon. JAMES LINDSAY, M.P. in the Chair.

BARRACKS.

By Lt.-Col. T. B. Collinson, R.E.,

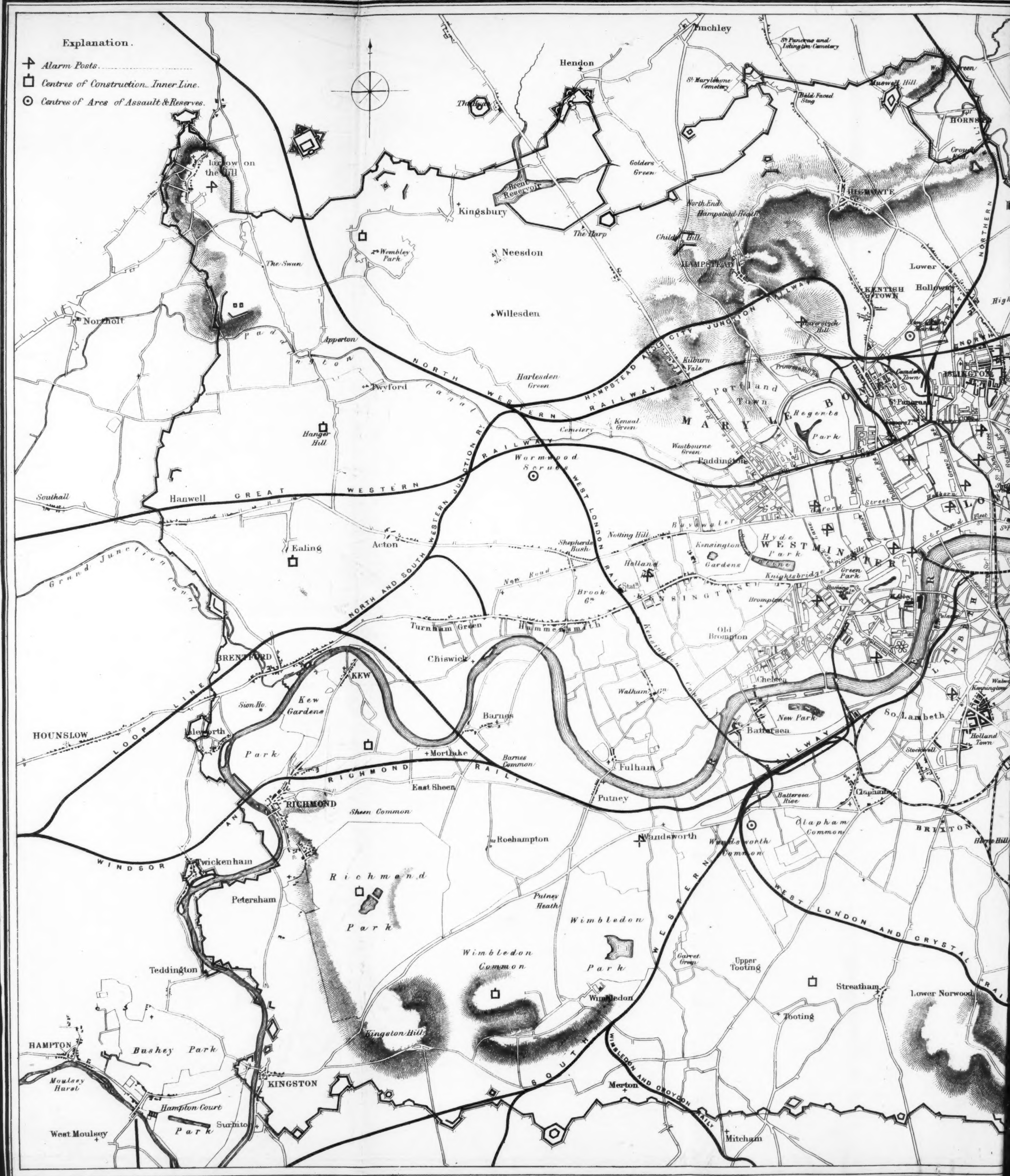
Instructor of Military Architecture, R.E.E. Chatham.

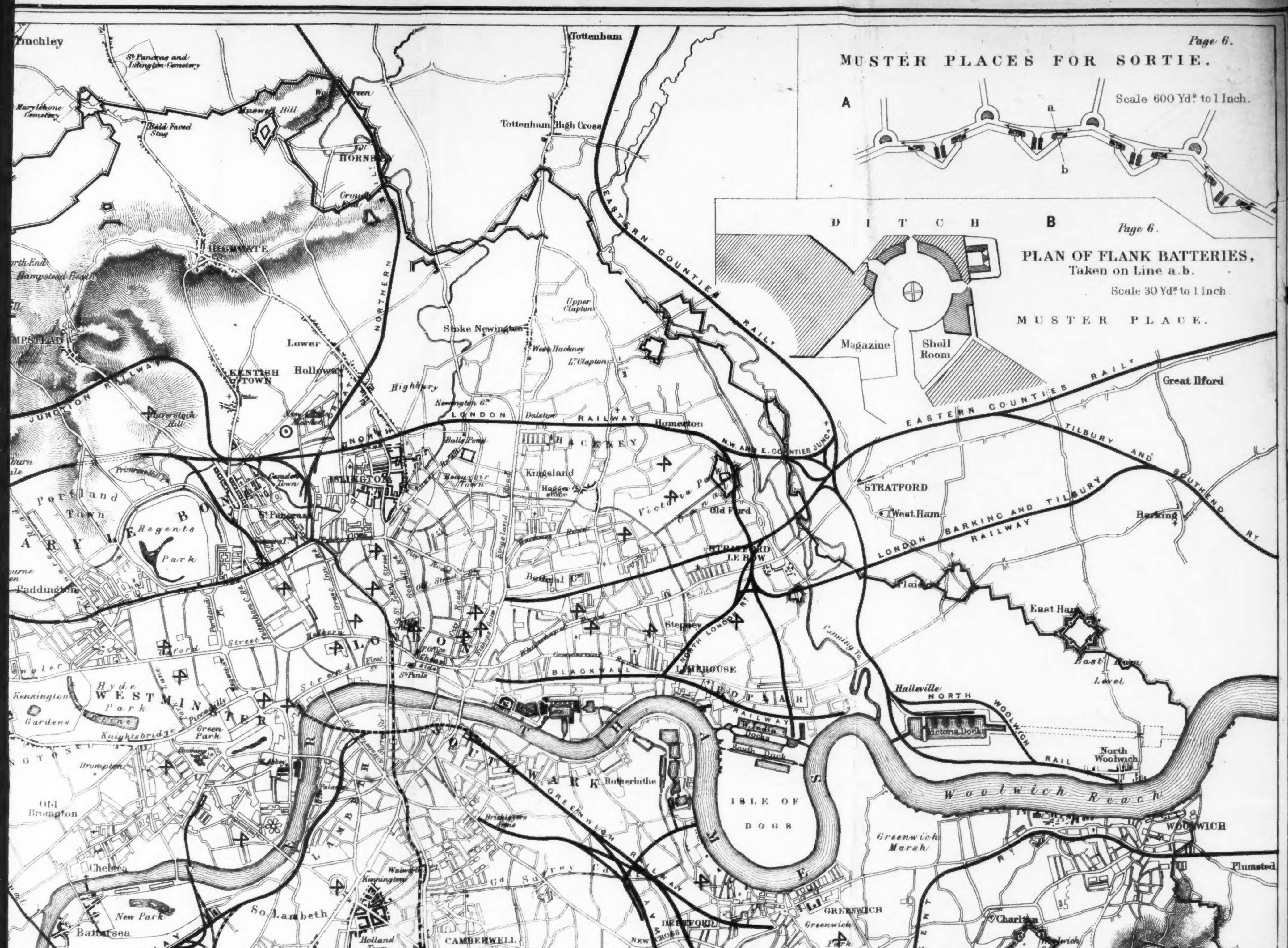
The Chairman: I have the pleasure of introducing Lt.-Colonel Collinson, R.E., who has been kind enough to come here this evening for the purpose of reading a paper on the subject of barracks. It is a subject he is well qualified to dilate upon. We all know it has become of late years a most important subject. It is only to be regretted that it was not important many years ago, for then our soldiers would have been in a very much better position than they are now. Still it is a subject which is engrossing more of the public attention than formerly, and we know that when public attention is brought to bear upon a question of this sort, the public finances will be brought to bear upon it also.

Lt.-Col. Collinson: The subject of this paper is the plan and arrangement of barracks. The object of it is, without going into details of construction, to endeavour to reduce the requirements in barrack buildings to principles, and to extract therefrom a few general laws for their arrangement, and a few simple plans of buildings applicable to barracks generally.

That certain general principles of arrangement and a certain uniformity of buildings can be attained, must be evident to all officers who have been quartered in permanent camps; and that it will be economical and advantageous to the service to attain both, must be evident to all who have had opportunities of observing the irregularities of the arrangement of our numerous old barracks; and finally, that this is a suitable time for the consideration of such a systematic attempt will appear from the Report of the Sanitary Commission to the Secretary of War last year, in which it is stated, that to provide every soldier with the cubical space recently laid down by the Secretary of State as necessary for his health, will require an additional accommodation of one-third to the barracks in the United Kingdom, or for between 20 and 30,000 men. If, therefore, owing to this cause and to the changes in the disposition of troops consequent on railroads and telegraphs, there is a probability of a considerable alteration to and increase in barracks, a project for reducing the arrangement of them to principles, and for establishing types applicable to the different classes of military buildings, is a fair subject for the discussion of the Royal United Service Institution.

To face page 538.




Page 6.
MUSTER PLACES FOR SORTIE.
A
Scale 600 Yds. to 1 Inch.
a
b
DITCH
B
Page 6.
PLAN OF FLANK BATTERIES,
Taken on Line a.b.
Scale 30 Yds. to 1 Inch.
MUSTER PLACE.
Magazine
Shell Room
THE
LINES OF LONDON
FROM PLANS PREPARED BY
COL. SHAFTO ADAIR, F.R.S.
AIDE DE CAMP TO THE QUEEN.
MILES
Note. Railways in progress are shewn thus
Finchley
Tottenham
Tottenham High Cross
Highgate
Hornsey
Stoke Newington
Upper Clapton
Lower Holloway
Kentish Town
Highbury
Hackney
Homerton
Kingsland
Islington
Camden Town
St. Pancras
Regents Park
Portland Town
Paddington
Kensington Gardens
Hyde Park
Westminster
London
Southwark
Green Park
Knightsbridge
Brompton
Old Brompton
Chelsea
Battersea
New Park
So. Lambeth
Lambeth
Kennington
Camberwell
Peckham
New Peckham
Nunhead Cemetery
Brixton
Clapham
Clapham Common
Wandsworth Common
Dulwich
Forest Hill
Sydenham
Streatham
Upper Tooting
Tooting
Lower Norwood
Upper Norwood
Crystal Palace and Park
Penge Common
Beckenham
Mitcham
Bromley
Chiselhurst
Southend
Rushey Green
Lewisham
Lee
Deptford Common
Deptford
Greenwich
Greenwich Park
Blackheath
Kidbrooke
Eltham
Charlton
Woolwich Common
Shooters Hill
Woolwich
North Woolwich
Woolwich Reach
Plumstead
Greenwich Marsh
Isle of Dogs
Rotherhithe
Limehouse
Poplar
Blackwall
Stepney
Stratford le Bow
Old Ford
Victoria Park
Stratford
West Ham
Plaistow
East Ham
East Ham Level
Halleville
Victoria Dock
Barking
Great Ilford
Eastern Counties Railway
London Barking and Tilbury Railway
Tilbury and Southend Ry
North Woolwich Rail
North London Ry
North London Railway
West London and Crystal Palace Railway
Bromley and Farnborough Railway
Mid Kent Railway
South Eastern Railway
Greenwich Railway
North Kent Ry
Junction Railway
Great Northern
St. Pancras and Islington Cemetery
Marylebone Cemetery
Hampstead
Muswell Hill

J.R.Jobbins.

Evening Meeting.

Wednesday, April 30th, 1862.

Major-General the Hon. JAMES LINDSAY, M.P. in the Chair.

BARRACKS.

By Lt.-Col. T. B. Collinson, R.E.,

Instructor of Military Architecture, R.E.E. Chatham.

The Chairman: I have the pleasure of introducing Lt.-Colonel Collinson, R.E., who has been kind enough to come here this evening for the purpose of reading a paper on the subject of barracks. It is a subject he is well qualified to dilate upon. We all know it has become of late years a most important subject. It is only to be regretted that it was not important many years ago, for then our soldiers would have been in a very much better position than they are now. Still it is a subject which is engrossing more of the public attention than formerly, and we know that when public attention is brought to bear upon a question of this sort, the public finances will be brought to bear upon it also.

Lt.-Col. Collinson: The subject of this paper is the plan and arrangement of barracks. The object of it is, without going into details of construction, to endeavour to reduce the requirements in barrack buildings to principles, and to extract therefrom a few general laws for their arrangement, and a few simple plans of buildings applicable to barracks generally.

That certain general principles of arrangement and a certain uniformity of buildings can be attained, must be evident to all officers who have been quartered in permanent camps; and that it will be economical and advantageous to the service to attain both, must be evident to all who have had opportunities of observing the irregularities of the arrangement of our numerous old barracks; and finally, that this is a suitable time for the consideration of such a systematic attempt will appear from the Report of the Sanitary Commission to the Secretary of War last year, in which it is stated, that to provide every soldier with the cubical space recently laid down by the Secretary of State as necessary for his health, will require an additional accommodation of one-third to the barracks in the United Kingdom, or for between 20 and 30,000 men. If, therefore, owing to this cause and to the changes in the disposition of troops consequent on railroads and telegraphs, there is a probability of a considerable alteration to and increase in barracks, a project for reducing the arrangement of them to principles, and for establishing types applicable to the different classes of military buildings, is a fair subject for the discussion of the Royal United Service Institution.

In bringing forward such a proposition, it must be understood that, although I have received the assistance of the office of the Inspector-General of Fortifications, and of other military departments (because the subject forms part of the course of military architecture, of which I have the charge, at the Royal Engineers' School at Chatham), the particular propositions that will appear in the course of the paper must be considered as given on my own authority only, as the expression simply of my own views; and further, that I cannot claim the merit of inventing any new system of barrack-building, for the barracks existing already in the British empire have left no field for an inventor—my office has been that of a curator of a museum, that of arranging the most characteristic and favorable specimens of barracks I can find, and from them and the books of regulations endeavouring to discover a law for their formation.

At the commencement of this subject, the first consideration is, "What is the object of the buildings?" in former times, before the invention of gunpowder, there was no difficulty in answering this question: then all military buildings were designed solely for defensive purposes; the wants and conveniences of the garrison were subservient to those for the defence of the building; but, the ordinary construction of walls being proof against the weapons of the attack, the military architect requiring only for defensive purposes a stout wall with flanks, could arrange it to form part of the cover for the garrison and stores, and thus arose that description of military architecture which we call castellated.

But with the invention of gunpowder arose the necessity of having large fortresses with earthen ramparts and covered escarps, and the consequent necessity of separating the buildings required for the cover of the garrison from those for the purely defensive objects; and the former became more and more assimilated in character to the ordinary buildings of civil life, and now in England we have become so habituated to consider the whole island as one great fortress within which the military buildings may be constructed, with a view solely to economy and health, that the defensive element has been very nearly lost sight of altogether. If, however, we reflect that a large proportion of our army is stationed abroad, in stations selected for purely defensive reasons, and that even in the United Kingdom a considerable proportion of the troops kept in it will from henceforth be in strategetical or at least military positions, it appears reasonable that the defensive element should be considered in treating the question of barracks generally for the whole army.

Indeed, if we could get a literal answer to our question with respect to the military stations in England, it would doubtless be found that almost all of them were originally selected for purely military reasons; and if there is a purely military object in stationing troops in any particular place, the selection of the site, and the arrangement and construction of the buildings, should be chiefly ruled by the same considerations.

There are two other important considerations which must combine with that of defence, in ruling these questions, viz.:

2dly. Administration, or the duties to be performed in the barracks.

3dly. Health.

None of these then can be omitted in the questions of site, arrangement, and construction; it is the problem which the military engineer has to

solve, of fitting his barracks and buildings to the locality, so as to give to each of the three its maximum value possible, giving weight to them in their relative order of importance.

I propose to consider each of them in order ; and as a military engineer I naturally consider defence as the main object of barracks, without which there would be no object in having troops at all.

Defence.

For the purposes we have now under consideration, this part of the subject is simple, and will cause little discussion from those concerned in the other two points; for we are not dealing now so much with sites, as with arrangement on a given site. Still, as I wish to apply some principles to the arrangement of a large military station, I must refer to the opinions given in the Report of the Sanitary Commissioners on Barracks and Hospitals to the Secretary of State for War last year (which will be more fully quoted afterwards), that "an unhealthy site leads to a constantly recurring loss of efficiency among the troops from preventible diseases, and this fact ought to weigh forcibly against selection of ground for purely military purposes. What we contend for (they say) is, that all the circumstances and conditions should be weighed together before arriving at a conclusion." But it must be borne in mind that, if defence enters into the question at all, the requirements for it are so imperative that in general a position is fixed absolutely by the nature of the ground. If it is to be considered at all, it must necessarily be the first consideration. In planning the general arrangements of any new military station that is not included in some other line of defence, the first thought of the military engineer must be, how is this station to be defended by the smallest number of men against an attack without artillery ? How are the defenders to be supplied with ammunition and provisions, and how are they to keep up their communications with the places representing to them the main body ?

The sites being determined, the arrangements for the defence of any particular block of buildings against musketry can be made without material alteration in the plan or construction of the buildings as proposed for their ordinary purposes. There are many instances of defensible barracks in the United Kingdom; sometimes it has been done by enclosing the space with a loopholed and flanked wall, as in the original plan at Preston; sometimes by arranging the buildings themselves to flank each other, or by concentrating the buildings into a compact form, systematically arranged in faces and flanks. By placing any of the buildings, specially strengthened, at the angles of a rectangular block of barracks, the whole could be defended from four points, and the ordinary barrack wall could be arranged so as to form an outer enclosure, or line of defence beyond the buildings themselves.

The efficiency and advantages of the simplest kind of flank defence was well illustrated in the hotel at Newport, in the Rebecca riots, when owing to two bow windows in the front, a few soldiers held in check the rioters, who would otherwise have been in possession of the town.

A fort or castle is not required at every military station, but it seems

only a reasonable answer to the first question, that the buildings should be so arranged that the garrison can turn out and form a line with the least possible delay, and under cover, ready to march wherever they may be required, leaving the smallest possible number of men behind to keep their barracks and stores in perfect security.

Administration.

The next question that the military engineer would naturally ask himself is, "What are the duties to be carried on in this establishment?" for the construction and disposition of the parts of it should evidently be suited to those duties in the most efficient and economical manner; and, as we are dealing with a military body whose efficiency depends in a great measure on organisation, it is the more essential that very careful consideration be given to the arrangement of the dwellings, with the especial view that they shall be in harmony with that organisation. To speak as an engineer, I should say, that the more the buildings fit the machinery of organisation, the less friction will there be in using them.

In order to understand clearly the administrative wants of a military station in the matter of buildings, we must take into our field of view such a section of the army as will contain at least one complete unit of each of the different departments required for its existence. Organised as the British army is, the brigade or district constitutes this one complete self-contained section. A general officer's command in a district or garrison at home or abroad is a specimen of a completely formed articulate military body, consisting of certain internal organs called the staff, and of other external members, called the combatant or regimental force.

These may be briefly described as follows:—

1st. *The Staff.*—1. The General Officer commanding, who is the head and centre of motion.

2. The Adjutant-General and the Quartermaster-General, who may be represented as the mouth and eyes of the general.

3. The Commissary-General, who supplies money and provisions to all the force.

4. The Military Storekeeper, who has charge of ammunition and war stores of all descriptions, excepting provisions.

5. The Commanding Engineer, who is responsible for the efficiency of the defences, and who is the constructor of the force.

6. The Principal Medical Officer, who guards the health of the troops.

7. The Barrack Master, who has charge of all quarters after they are built, and of all furniture, bedding, and utensils connected with them.

8. The Chaplain, the Inspector of Schools, and the Inspector of Musketry, for the moral, intellectual, and physical education of the troops.

9. The Military Train, for transport.

10. The Governor of the Military Prison.

2nd. The *Combatant or Regimental Force,* which are the members for whose service the internal organic staff exists, consists of—

The regiments or battalions of Infantry;
The regiments of Cavalry;
The batteries of Artillery.

If it was a question of putting such a specimen of the body military into cantonments in the field, the regimental force would of course be placed in the foremost line, towards the enemy, and the departments of the staff in secure positions in rear. In a permanent military station, or garrison, supposed to be equally exposed on all sides, and dependent on itself for its own defence, the natural mode of carrying out the same principle, would be to place all the regimental or combatant forces round the exterior or circumference of the station, and all the internal organs, or staff departments, in the interior of it; the former being thus most commodiously placed for defence or offence, and the latter for security and communication.

The office of the general and his two chief staff officers would be in the most central and accessible part of the station; that of the commissary-general, containing the military chest, would be in the most secure situation, and his storehouses, to and from which there would be a regular daily communication for provisions with all parts of the station, would be, next to the general's office, in the most central position; and next to them in importance of centrality, if not before them, would come the barrack-master's office and storehouses; for he has incessant communications with all the regimental force concerning quarters, and furniture, and bedding, and fuel, and light, and water; in short, all those household wants which are daily felt by everybody. He, however, in addition to his central storehouses, must have in each regimental barrack what may be called expense storehouses, for bedding, fuel, and furniture; whereas the store-rooms of the regimental quartermaster, who receives the provisions from the commissariat, should contain only one day's supply.

The most important consideration for the engineer department is facility of access to land and water transport, on account of the heavy and bulky nature of the materials they deal with. Here would be the great workshops of the station, and therefore the barracks of the sappers, who would be chiefly employed in them, should be near the same place; and the commanding engineer's office also.

The military storekeeper should also have access, as far as possible, to land and water transport, as he has to deal with guns, and carriages, and such like heavy articles; his stores being for the most part of very valuable nature, should be placed in a secure position. The principal magazine of gunpowder would of course be placed in a site specially selected for its security from fire and injury, and separated from all other buildings. Expense powder magazines would be required in each regimental barrack.

The hospitals of the army are now so organised that they consist of an assemblage of so many regimental hospitals into one establishment, having each its separate regimental building, in which the sick are treated by their regimental officers; having also special wards for special diseases, and certain staff buildings common to the whole establishment. The regimental part consists of the wards, and rooms for nurses, orderlies, lavatories, &c. The staff buildings include the surgery, dispensary, kitchen, store-rooms, orderlies' rooms, &c. and offices.

At a large military station there should be one such hospital establishment, if a suitable site can be found for it; the selection of which must be ruled solely by sanitary considerations. It is not absolutely necessary,

but very desirable, that the site should be within the general line of defence. If the regimental barracks are so situated that any one of them would be more than one mile from the site of the hospital, that establishment should be divided, and part of it erected on some suitable site especially for such barracks.

The office of the principal medical officer should be at the general hospital.

The barracks of the military train should be situated in the most convenient place for access by carriage roads to all the staff and regimental buildings of the station, as their duties connect them pretty equally with all branches of the service.

It is hardly necessary to mention the other departments of the staff, because they require little more than rooms for their personal offices, excepting the educational and recreation branches, which of late years have been increased and organised to such an extent as to form considerable departments of the staff of the army in themselves. It is convenient, though not, perhaps, strictly correct, to class them together; for their buildings are more interchangeable with each other than with those of other branches, and some are on rather debateable ground between the two. Education may be said to include all chapels, schools, practice-grounds, drill-sheds, and gymnasiums. Recreation may be said to include libraries, reading-rooms, canteens, ball-courts, quoit and skittle grounds.

The school organisation of the army is staff, and not regimental; the schoolmasters are under the immediate direction of the staff. Therefore, the school establishments of a military station may be collected at one spot, subject only to the proviso, that it is not too far from any one of the regimental barracks; otherwise, concentration is advantageous for school purposes. The gymnasium of the station, for only one gymnasium regularly organised as a school of exercise would be required at a station, might be at the same spot; and also the soldiers' library, considering the latter as merely a place for the custody of the books, from which the men could draw them for reading at their own barracks. Drill-sheds being required for regimental purposes only, should be part of the regimental barrack; and rifle practice ranges must be, of course, at the nearest suitable locality, which should not be more than two miles from the centre of the station.

There does not exist in the British army any systematic instruction of soldiers in industrial trades for the sake of instruction, and the only mode of employing soldiers at such useful trades without incurring an unremunerative expenditure is through the means of different departments of the army which requires artificers, and do now employ civil artificers to carry on certain of their duties. In the Engineer department, and the Store and Barrack and Commissariat departments, and the Military Train, artificers of almost every trade could be effectively and economically employed; but, as part of the school organisation, probably the only crafts that could be effectively introduced are the same which form part of the regimental system—tailors and shoemakers.

The other half of this semi-attached couple which I have unceremoniously joined together, the recreative, is more difficult to deal with on account of the variety of wants included in it, which come under no known military

law. We wish to provide the soldier with healthy recreation, and with what may be called recreative relaxation and social recreation, and such recreation as shall act as a counter attraction to, and substitute for, the low description of public houses and shops which spring up round a military station.

The difficulty is to provide what shall be efficient and economical to be efficient, and at the same time sufficiently accessible to be a real relaxation. Such establishments as reading rooms, where smoking and tea and coffee is provided, and quoit and skittle grounds, and small ball courts, would probably be most effective as part of the regimental barrack, so as to be always available to the soldier by day and night, without leaving his own barracks. They are establishments that require little outlay beyond the furniture of a comfortable room, and a small current expenditure, and could therefore be economically managed in a regiment. But the canteen (which is never a regimental establishment, but always held by a lessee or contractor under the War Office) should be concentrated in one or two places according to the size of the station, otherwise it will not be sufficiently remunerative to enable the lessee to provide such attractions as will counteract the public houses outside. It may be near the library, but not connected with it, because they are two establishments under different management, and, to some extent, in rivalry. The racket court and large ball court, and other quoit, skittle, and cricket grounds would be properly placed near the canteen. Those rooms called day rooms, recently added to some barracks, could be used as regimental reading rooms.

The Regimental Force.

And now, having made this brief analysis of the internal organs of this individual specimen of the military establishments, there remains to be considered the requirements in position and interior arrangements of buildings for the active members of the body, or the infantry, cavalry, and artillery (the engineer barracks having been already provided for).

As this forms the essential part of this paper, I propose to take each of these three branches separately, for the interior arrangement of its buildings, and to consider now only their general distribution in the military station.

For administrative purposes, which we have now under consideration, the organisation of the army is regimental; the regiment or battalion of infantry, the regiment of cavalry, and the brigade of artillery, form the units of the brigade, just as the brigade forms the working unit of the army. The location of the force should be therefore by regiments; each barrack should contain a regiment complete, and nothing more than a regiment, so that the commanding officer of it, who is the person solely responsible to the general for its efficiency, shall be the sole authority within its walls, and each regimental barrack should contain all the establishments required for it, which are not included in any of the staff departments already considered.

The positions of the regimental barracks for the requirements of administration would be much the same as those for defensive purposes,

namely, round the circumference of the staff buildings, on such commanding points enclosing the whole position as cover the ground from barrack to barrack, and have access to good carriage roads both to the centre of it and also to the principal high roads of the neighbourhood; by such an arrangement the different barracks, and such other buildings as the church and military prison, would form a kind of chain of posts round the position, the infantry barracks being placed on the principal commanding points, and the cavalry and artillery being placed with regard to facility of access to the main roads on either flank, so that the whole brigade could move in its regular order of march in any direction with the least delay.

The site of the permanent barracks at Aldershot affords a good study for such an arrangement.

Health.

It is probable that in general the sites for regimental barracks recommended by administrative and defensive considerations would be also found to be the most healthy; but in order that the general requirements of this very important third division of the subject may be fully represented, I cannot do better than quote the opinions of the Sanitary Commission before mentioned, as the latest and best authority upon it.

With respect to selection of site, they say—

The position of a barrack must be primarily determined by military reasons; but wherever there is a choice of position, it need hardly be stated that a healthy country site should be chosen in preference to a town site, that the vicinity of marshes, stagnant water, muddy banks, and sites generally where malaria exists, and produces its usual results among the civil population, should be avoided; that there should be good available water supply, sufficient elevation to ensure good drainage to an accessible outfall; that a porous subsoil should be selected in preference to a retentive one; and that the area of ground should be large enough not only for the healthy disposal of the buildings and for exercise and recreation, but for preventing encroachments of the civil population.

The Regimental Barrack.

Infantry.

The site being settled, what are the requirements in the internal arrangement of the regimental barrack? Those for *Health* should in this case be first mentioned, that they may be borne in mind in considering those for administration and defence. Here again we cannot do better than take the authority of the Sanitary Commission of 1861.

Block Plan.—In barracks, as well as in all buildings where a large number of human beings are to be lodged together, it is most advisable, as a general principle, to place nothing likely to affect injuriously the purity of the air in the same building with the inhabitants. Stables, kitchens, latrines, and baths should therefore be built away from them. The building should be arranged in the simplest manner possible. Squares with closed angles should be, as far as possible, avoided. The great object to be aimed at is to have free external ventilation all round the buildings; in temperate and cold climates to have as much sunlight as possible, and to avoid a purely northern exposure for barrack rooms. One of the simplest and best arrangements for barracks is a single line lying north and south, if possible to allow the sun to shine on both sides of the range every day. Several parallel blocks, at sufficient distance from each other to enable the whole outer wall surface to be freely exposed to the sun during the day, might be

used on some forms of ground. Arrangement in square might also be adopted for large barracks, provided the angles of the square were left open.

Arrangement of Buildings.—No part of a barrack, whether for sick or healthy men, should be placed too close to the boundary walls. Latrines, cookhouses, stores, and other similar buildings, can be placed between the barrack and the wall, but the arrangement should be such as not to interfere with its external ventilation.

Barracks, as well as all populous buildings, are best constructed of only two stories of inhabited rooms. Three stories are not objectionable for healthy people, though objectionable for sick. Four stories should only be resorted to when, from the dimensions or form of the ground, it is absolutely necessary to adopt this number of floors.

Dry stores, staff and regimental rooms for administration, day rooms, libraries, and reading rooms, may be placed without detriment on the ground floor with mess rooms over, when it is necessary to do so. Basements should never be used for barrack rooms, nor indeed for human dwellings; they are always more or less liable to damp, stagnation of air, and deficiency of sunlight, and are well-known nurseries of disease in civil life.

The organisation of a regiment of infantry is similar to that of a brigade. the regimental staff consists of similar members and performs similar functions for the regiment to that of a brigade, and the companies correspond to the battalions. There is the commanding officer, who is the head and centre of the regiment, the adjutant, the paymaster, the quartermaster, the surgeon, and the musketry instructor, and then there are the companies, beyond which the organisation of the army does not virtually extend; the subdivision of a company into squads is for better supervision only, the captain being solely and entirely responsible for the efficiency, clothing, pay, arms, and messing of the whole company. The company therefore is the lowest unit that should be considered in barrack arrangements. It is almost impossible, owing to the frequent alterations in the strength and even establishment of a company in the British army to ensure that certain quarters, however rightly designed, shall be always preserved intact to one company, but the endeavour should be to have such an arrangement that the head quarters of a company shall be as clearly designated in the building as the head quarters of a regiment.

The arrangement of an infantry regimental camp shows the complete requirements for administration and defence, and the French permanent camp of Chalons carries out that arrangement almost completely. In a permanent barrack, having no enemy in front, the officers' quarters and the staff buildings would be more suitably placed in the front line, together and detached from the men on either flank of the line of companies quarters, parallel or at right angles to it, according to the length of parade required. That parade, however the buildings are disposed, should be sufficient to enable the regiment to form in line and to march past in column; for an ordinary regiment of the line about 900 feet by 250 feet is required for this purpose. The parade, to speak nautically, is the quarter-deck of the barracks, and, as long as it is within some kind of boundary, it is better that it should be outside the buildings, which can then be more concentrated for defence.

The staff buildings should contain accommodation for the commanding officer's office, the orderly room, paymaster's office, court-martial room, the quartermaster's office, and store rooms and workshops. For both administration and defence the best position for the whole of these is in the centre of the front line of companies' quarters, sufficiently advanced to distinguish them; the commanding officer's office being in front overlooking

the parade, for this should be the most central and conspicuous building in the barrack; it contains the colours and records of the regiment, and and from it all orders issue.

A synopsis of barrack accommodation was compiled in the office of the Inspector General of Fortifications a few years ago, from authorised plans and opinions of officers of all branches, and, though not an authoritative document, I shall quote it as giving what may be considered as the custom of the service up to this time. It allows only 12 feet by 10 feet for the commanding officer's office, which certainly appears very small.

The orderly room should be next to his office, and should contain space for about 15 persons to write. This synopsis allows 18 feet by 12 feet, which appears small.

The paymaster's office should be about the same size as that of the commanding officer, containing a fire-proof safe for his military chest.

The court-martial room should be about the same size as the orderly room, the synopsis allows 18 feet by 18 feet.

The quartermaster requires a room about 30 feet square to hold the annual clothing of the regiment, the spare stores and baggage and regimental necessaries and kits of absent men, and a room about 20 feet by 15 feet for the daily provisions of the regiment, as received from the commissariat department.

The tailors' and shoemakers' shops of the regiment, which are both under the quartermaster, would together require nearly the same space as the storerooms, and could therefore be suitably placed over them. The armourers' shop, also under the quartermaster, should be in a detached building on account of the fire and noise, and would therefore be suitably placed in a yard behind the staff building. In the same yard could very properly be placed such expense storerooms as the barrack-master required for fuel, bedding, straw, and furniture, and also the fire-engine, which is under his care: they would thus be in the most central position for convenience and saving of labour.

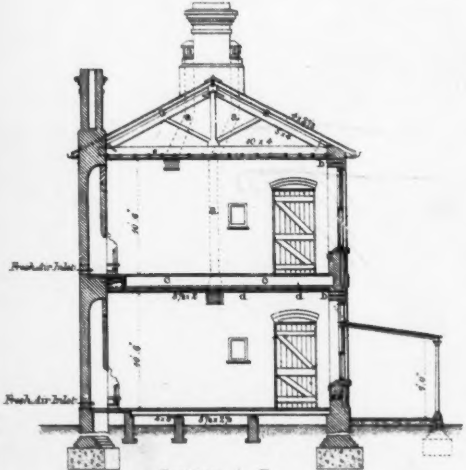
The Companies' Quarters.

The cost, the efficiency, and the convenience of the barrack depend chiefly on the arrangement of the company quarters. The ordinary strength of a company in an infantry regiment may be taken at 3 officers, 4 sergeants, and from 80 to 90 rank and file: but from the latter, for the present consideration, must be deducted the proportion of married men, who by a late order of the Secretary of State are provided with special quarters or receive an allowance of lodging money to find their own quarters; this proportion is 8 per cent., which leaves an average of about 76 men. A proportion of the company sergeants are also allowed to be married, but the system of responsibility in the British army requires that the sergeants should be close to the men, especially the colour and pay sergeants; the company quarter should therefore include 4 small rooms for them, whether married or single. In determining the size of the company quarter, the first consideration is that the rooms should be comfortable. The barrack room is the soldier's home; and, whatever other means of recreation are given him, the place where he sleeps and keeps his things should be his real home. A room of 70 or 80 men would not be com-

To face page 549.

COLCHESTER BARRACK.

Plan of Half of One Unit of Infantry Qr. for a Company consisting of 4 Sergeants. and 76 Single Men allowing 600 Cubic Feet to each.

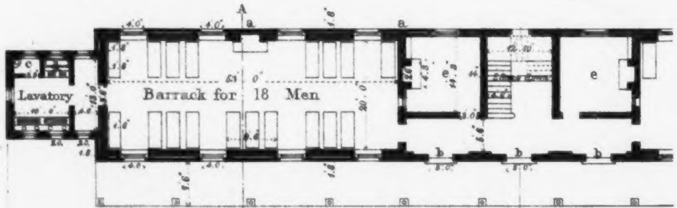


Section A. B.

Scale 5 Feet to One Inch.

Note. a. a. *Are the Foul Air Flues.* b. b. *Louvred Ventilators.*
c. c. *Joists 11" x 2½ - 12" apart.* d. d. *Joists 12" x 3 - 7 ft. apart.*

Half of Front Elevation.



Half of Ground Plan.

Note. a. a. *Fresh Air Inlets.* b. b. b. *Sliding Doors.* c. *Night Urinal & W.C.* d. *Foot Baths.* e. e. *Sergeants Rooms.*

SCALE OF 10 5 0 10 20 30 40 50 60 70 FEET

J.R. Jobbins

J R Jobbins

NORMAL REGIMENTAL BA

For Two Field Batteries, Peace Establishment.
and One on the Se
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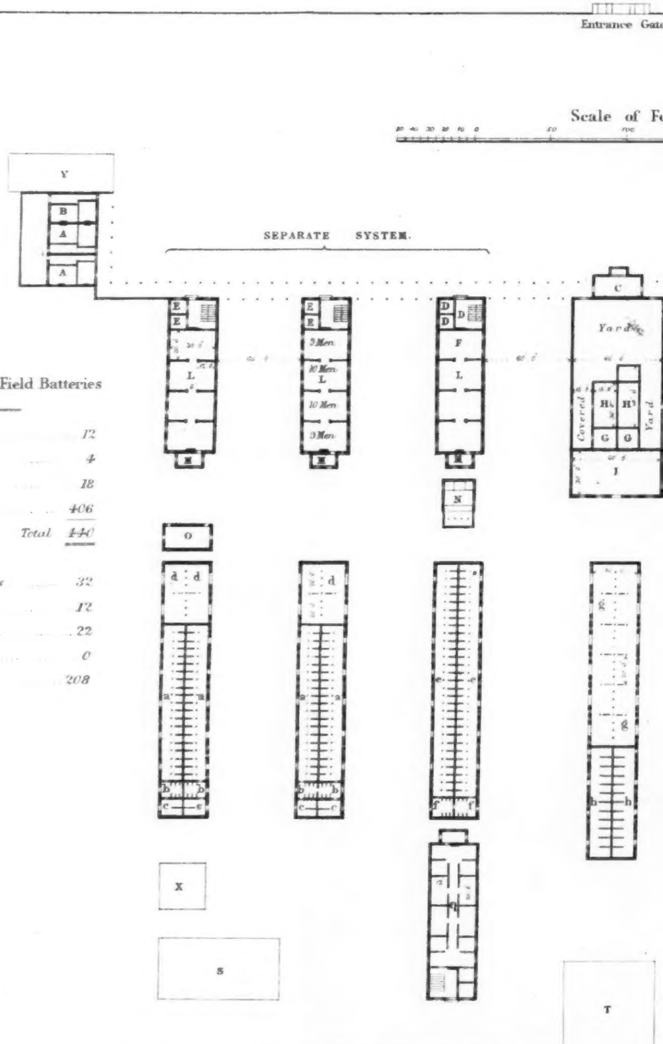
To face page 549.



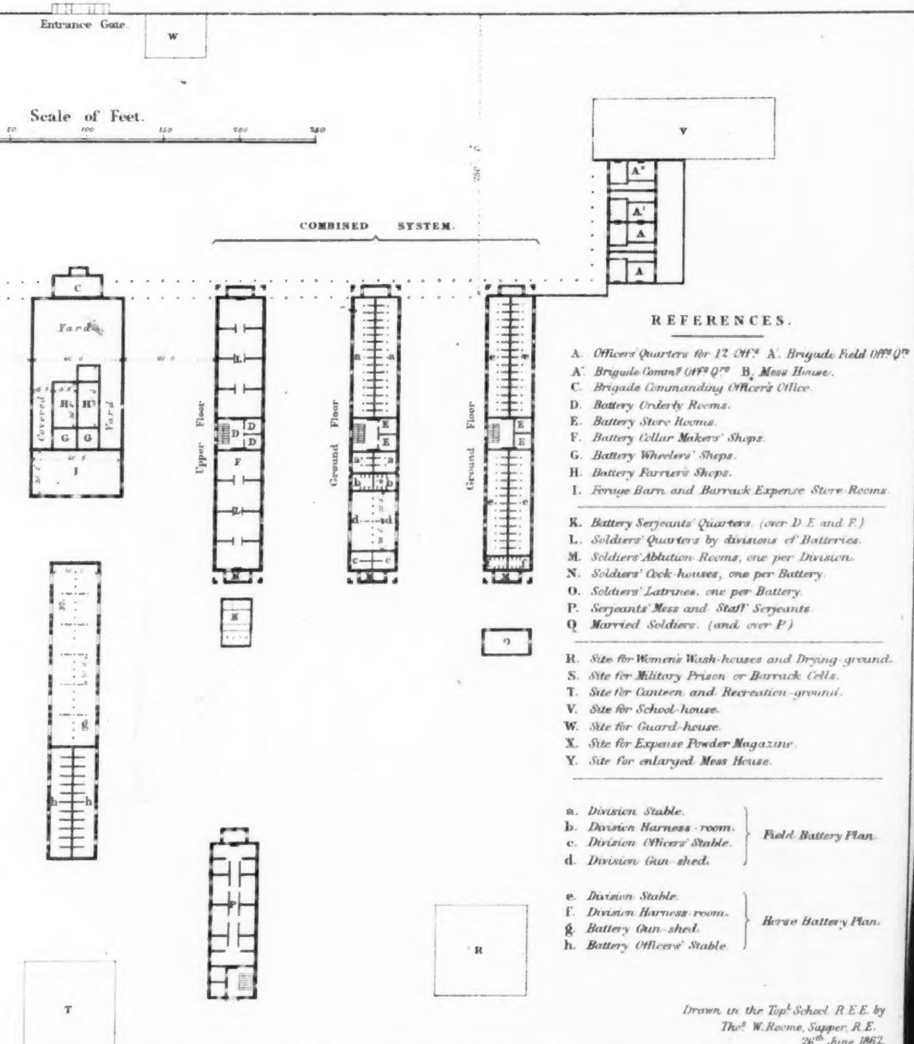
Accommodation for 2 Field Batteries

Officers	12
Staff Serjeants	4
Serjeants	18
Rank and File	406
Total	440
Including Married Soldiers	32
Guns	12
Wagons and Carts	22
Horses — Officers	0
— Troop	208

Plate 2.

AL BARRACKS — ARTILLERY.

ishment. One Battery on the Combined System
n the Separate System.
tions necessary for a Horse Battery.



Drawn in the Top.l School R.E.E. by
Tho.s W. Roome, Sapper, R.E.
26th June, 1862.

J.R. Jobbins

fortable; it would be noisy, inconvenient of access, and difficult of supervision; on the other hand a small room would be more difficult to ventilate and more costly and also difficult for supervision and cleaning: 18 appears to have been generally adopted as an average number for one room, so that 4 such rooms would constitute an ordinary company quarter. The sanitary commissioners before quoted recommend that the ablution room for the men to wash themselves should be attached to every room, instead of being all in one large room for several companies, which appears to be advantageous, because it promotes cleanliness, and places the room under the exclusive control of the company officers.

With respect to the cookhouse, there are two modes of arranging the cooking in a regiment; 1st, by giving each company a kitchen, which would also serve as a dining room: 2nd, by having one cookhouse for the regiment. There are several advantages in the former system; it corresponds to the company organisation, it keeps the barrack room cleaner and more quiet, and gives each company a sort of day room; but these are counterbalanced by the importance, indeed the necessity, in an army of having an uniform system of cooking, and by the advantages of supervision and cleanliness. The kitchens of a regiment in the field must be concentrated in one or two places, and there should be the same system in barracks as in the field.

The size of a barrack room to hold 18 men is fixed by the regulation of the War Office, giving to every man 600 cubit feet of space. This regution, which is the cause of the great expense of modern barracks, and of the present demand for increased barrack accommodation, has been fixed from the consideration that a man will vitiate and render unfit for respiration that quantity of air in less than an hour. This should be borne in mind by all barrack projectors, because the cost of the men's quarters was from 30 to 40 per cent. of the cost of a complete barrack when the regulation space was 500 cubit feet.

The width of a barrack room allowing a row of beds on each side, and space for a barrack table and forms in the middle, cannot be less than 20 feet. The barrack bedstead is less than 3 feet wide, and the Sanitary Commissioners recommend a passage of 2 feet between each bed; the synopsis allows 4½ feet lineal per bed, which has the advantage of increasing the height of the room and of reducing the floor space. Assuming the latter space, a barrack room to afford 600 cubic feet per man, and allowing 5 feet for a door, and 8 feet for a fireplace, should be about 45 + 20 + 13½ feet. There are two principal modes of arranging the rooms, 1st. Longitudinally, *i.e.* the length of the rooms being parallel to the general line of the building, with the beds along each side wall between the windows: 2nd. Transversely, *i.e.* the length being across the building, and the beds along the party walls and the windows at each end. The former is recommended by the Sanitary Commissioners on the consideration of fresh air, and is exemplified in the new cavalry barrack at Colchester. (Plates III. and IV.).*

* Plate II. shows the plan of what may be called a normal regimental artillery barrack and has been adopted from a project for a barrack by Capt. Belmas of the French Engineers. The artillery barrack only is here given in order to reduce the number of plates; it shows sufficiently the requirements of all three branches. The left half of the plate,

In the Colchester Barrack a unit of one room has been adopted, which is virtually the same as the company unit herein proposed. (Plate III. shows one block of the Colchester Cavalry Barracks, and illustrates the separate system.) Whatever the arrangement, the head quarters and main body of each company should have a distinct house to themselves, with a separate door and separate staircase; and this company unit would therefore include:

4 serjeants' quarters.
76 rank and file quarters, at least.
The company ablution rooms.

Married Soldiers.—In every regiment of 10 companies there are 7 staff serjeants (the hospital serjeant not being included) and 60 to 70 married men to be accommodated. Considering the variable number of married men, and the variable strength of a regiment, it appears reasonable to construct the married quarters on the same plan as the company quarter, with such light partitions that they could readily be converted into men's quarters without altering the main parts of the building. The Sanitary Commissioners recommend a floor space of 150 to 170 feet to be allowed to each family, which is a very fair allowance: at that rate a company quarter would accommodate 20 families; or five would accommodate all the staff serjeants, married men, serjeants' mess, and band-room. Such an addition will add considerably to the per-centage of soldiers' quarters.

The Regimental Barrack.

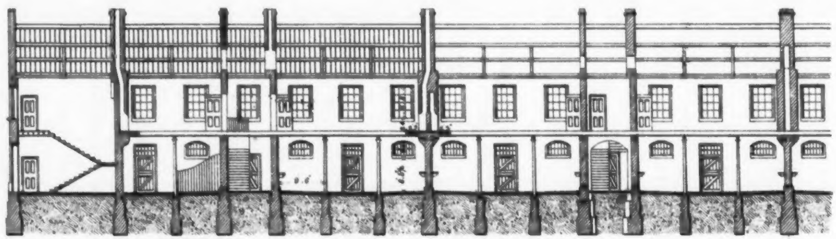
Cavalry.

The organisation of a regiment of cavalry of the line is, as far as barracks are concerned, virtually the same as that of the infantry. There is the same staff under the lieutenant-colonel, with the addition of a riding master and a veterinary surgeon; and there are troops, the captains of which are responsible for their efficiency, clothing, and appointments, and feeding of their men and horses; the squadron formation being one of evolution only in the British cavalry. The number of troops in a regiment, and the establishment of a troop, vary from time to time. For home service the average may be taken at 8 troops, each consisting of 3 officers, 4 serjeants, and 73 rank and file, and 50 troop horses.

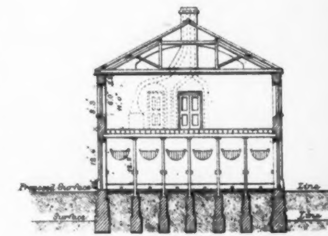
The arrangement of a regimental cavalry camp is similar to that of an infantry regiment; the horses are picketed by troops at right angles to the main front, with the tents in front of each line of troop horses, and the officers' tents in one line in rear. The arrangement of a cavalry barrack should be so far in accordance with this, that men and horses should be quartered by troops, and the men should be as close as possible to the horses; and they should be able to form in line as quickly and conveniently as possible. There are two modes of arranging a cavalry barrack under these conditions: 1st, by putting the men in the same building,

which represents the quarters for one battery of artillery on the separate system, also shows three units of infantry company quarter, each containing the accommodation stated in the text as required for one company. These three buildings are of two stories, each story containing one large room subdivided into four compartments by party walls 7 feet high, the beds being placed along these party walls and the windows in the main walls, of course, and a fireplace at each end.—T. B. C.

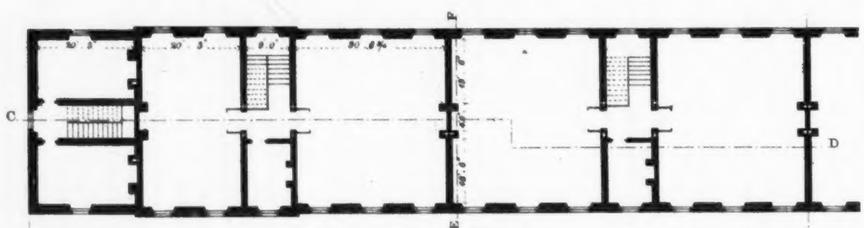
HALF PLAN AND HALF SECTION OF CAVALRY QUARTERS, PRESTON BARRACKS.



Half Section on the Line C. D.



Transverse Section on the Line E.F.



Half Plan of Upper Floor.

Table of Scantlings.

Tie Beams 11" x 5 to Camber 2⅞	
Queen Posts	5" x 3⅞
Principal Rafter	5 x 8
Braces	4 x 3
Straining Beams	7 x 5
Do. Sill	5 x 3
Ridge Board	8 x 2
Pole Plates	4 x 4
Wall Plates under Joists & Tie Beams	8" x 5" and 8" x 4"
Common Rafters	4 x 2
Ceiling Joists	5 x 2
Purlins	8 x 5
Templates to Do.	4 x 3
Floor Joists 3" x 24"	*Trimmer Joists ⅛ thicker than common Joists for every Joist they are to carry.*
Joists over Passage and Staircases	7 x 24
Ground Floor Joists, Oak	8 x 3
Sleepers to Do. Do.	4 x 3
Girders, Fir	10 x 4
Fillets, Ceiling Joists	1 x 1⅛

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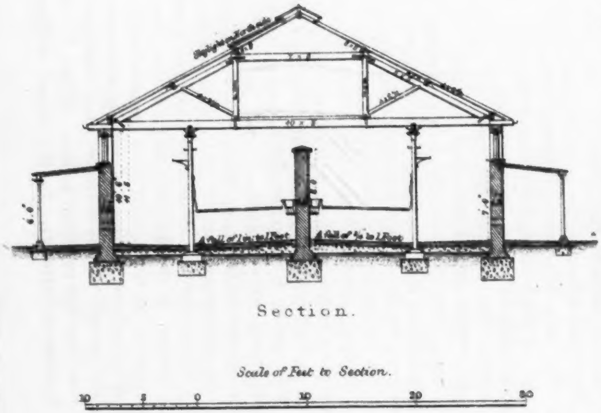
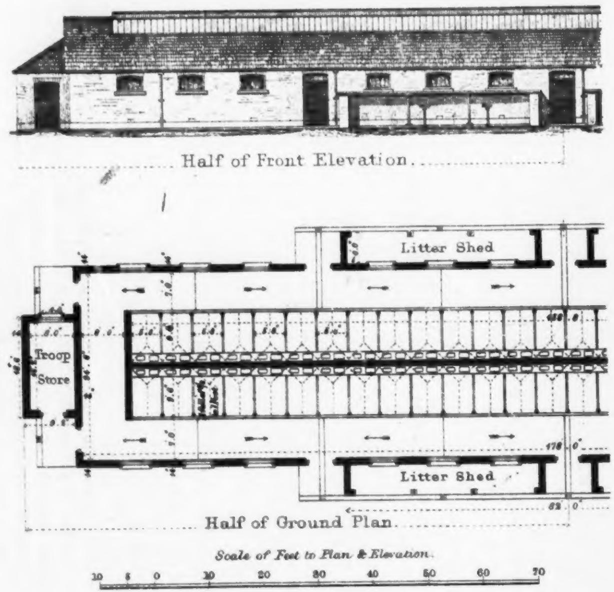
COLCHESTER BARRACK

Plan of Half of One Unit of Troop Stable for 56 Horses, allowing 1500 Cubic Feet to each.





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over the horses, which I will call the combined system; 2nd, by adopting the unit of infantry barrack for the men, and using a separate unit of stable; this I will call the separate system.

The Combined System.—The Sanitary Commissioners have expressed a strong opinion against this system. They say :—

These general principles (the unit of quarter, &c.) are applicable to all barrack-rooms. They involve a change in the manner of constructing barracks, especially those for cavalry, because, to give effect to them, requires the stables to be separated from the men's quarters. We have already pointed out the disadvantages of placing men's rooms over stables. The amount of cubical space per man, according to the new regulation, must be as great in infantry barracks as it is in cavalry barrack rooms over stables. A covered passage could be made from the men's rooms to the stables. The advantages to be derived would be very great as regards men; but it would be even greater as regards horses. After much experience, and attentive consideration of the subject, we do not hesitate to say that it is impossible to ventilate satisfactorily a stable accommodating a large number of horses, if anything beside the roof is interposed between the stable and the outer air; and that it is equally impossible to keep the air in men's rooms over stables pure and free from stable odour.

There are authorities who consider that the men's room being over the stables tends to keep an uniform temperature in the latter, which is one of the chief requirements for the health of horses, and that such rooms are not unhealthy. The system has the advantage of occupying a less total space; but the separate system, in addition to the sanitary advantages, allows of a greater simplicity in barrack buildings, and what is important in our service of greater flexibility. The combined system may, however, sometimes be necessary in sites of limited extent; and, therefore, one-half of the normal cavalry barrack is shown on this system, as adapted to the same French plan of barracks (see Plate II.) In it the accommodation for the men has been taken as the basis of arrangement, to which that for the horses has been fitted, each building containing one troop, men and horses. One of the buildings represents the upper story, where the men are placed, and two the lower stories, where the horses are placed. By taking the men as the basis of the arrangement, of course the upper stories contain the exact number of men, according to their cubical space; the space for the horses is therefore more limited. At Preston barrack there is an example of the combined system, in which the accommodation for the horses has been taken as the basis. Plate I. represents a block of Preston Cavalry barrack, and shows the ground floor occupied by the horses, and the upper floor occupied by the men. The stables run through the building transversely, with 12 horses in each stable, standing against the party walls, tail to tail, with a passage down the centre. This system is therefore not so simple nor so flexible as the separate system, though very compact.

The Separate System.—Colchester barrack is a favorable example of this system. The accommodation for the men is precisely that proposed by the Sanitary Commissioners for infantry, and the horses are placed in a line of large stables in the rear of, and parallel to, the men's quarters, each stable containing 56 stalls; there is a separate stable of special construction for all the officers' horses, and a troop storeroom to each stable. So placed, the stables will occupy a longer front than the men's quarters, and a longer front than the regiment in line. (Plate IV. shows one block of stables of Colchester barrack). In the normal artillery barrack here

shown (Plate II.) one-half is represented on the separate system, the unit of infantry company quarter being used for the men of the troop. Deducting the per-centage of married men, there is on the average about 68 rank and file of troopers to be provided for. The space of the eight men (76 being the infantry number) is there proposed to be allotted to the troop storeroom, which is required for the kits and equipment of absentees of the troop. The unit of troop stable there shown is on the same plan as the Colchester stable, and contains 56 troop stalls, and eight officers' stalls for the seven horses of the troop officers. This number allows six extra troop stalls and one extra troop officer's stall, and has been chosen with regard to the requirements for artillery. The buildings, being placed at right angles to the general line, can be at any convenient intervals, so that they do not exceed altogether the front of the regiment in line, which for an ordinary regiment of eight troops is about 1,000 feet.

With respect to details of construction of stables, I shall only mention, that no decided opinion has been given, that I know of, on the best number of horses to place in one stable, nor of the best position for the saddle racks; and probably horsemen never will be agreed on these points, more than on the size of a stall, or whether horses should be placed head to head, or tail to tail. By placing them head to head in a large stable, as in Colchester barrack, with a division wall 7 feet or 8 feet high down the centre, the advantage of a large stable for ventilation and supervision is obtained, and yet there is a complete division into two, for health and quiet; but then the whole stable must be wider than with the horses tail to tail. In the normal barrack plan, a width of 30 feet is taken, in order to have the same span of roof throughout the barracks.

Our horses appear to require more space than French horses; for the latter people do not allow more than 5 feet for the width of a stall, whereas the synopsis recommends 5½ feet; Colchester is 5 feet 8 inches; and Preston 5 feet 8 inches. The width is generally the same, viz. 30 feet for tail to tail, and 34 feet for head to head.

Staff Buildings.—The staff buildings of a cavalry regiment should be almost the same as those for infantry, and for the same reason situated in the same place. The difference of size, based on the absolute requirements, would be insignificant in cost; the quarter-master's storeroom, which is the largest part, should be as large as that for infantry, because he has the spare equipments of the horses; and the workshops above the storeroom should include the saddlers' shop. The farriers' shop should be in the yard behind, and have space for six smiths' fires; which, as one fire can serve 100 horses, will be ample for the regiment. This would require a space of about 50 feet by 18 feet, and the shoeing shed should be about the same size, having space for 12 horses at once.

If about 60 feet by 30 feet of this yard was covered with a light roof and had a partition down the centre, it would serve for farriers' shop and shoeing shed. The forage barn should be at the back of the same yard, that being the most central position for the men's quarters and stables, which is the great consideration, as the men have to come to it daily for the forage. It must be capable of containing at least 21 days' supply; 14 days' supply being the quantity which the contractor is obliged to have on hand in it. The synopsis allows a space of 35 feet by 18 feet for oats,

65 feet by 18 feet for hay, and 60 feet by 18 feet for straw. A two-storied building 100 feet by 30 feet would be sufficient for this purpose and for the barrack-master's straw store.

There are about 27 staff horses to be stabled, for which (to carry out the principle of separating the staff from the company or troop buildings) a special stable should be provided on the same plan as the others, in the rear of the staff buildings.

A riding school and open riding ground, or *manège*, form part of every regimental cavalry barrack; though probably, where there are several regiments close together, one large riding school would be found more useful than several small ones. The size of a regimental school depends on the average number of horses trained together in one squad or ride, which varies from 12 to 20. A squad of 15 horses, to go through the equitation drill, requires a space of about 150 feet by 50 feet. The *manège* should be in the same proportion and larger. The riding school should be close to the *manège*, and this latter should be on as level a site as possible, in a retired part of the enclosure, surrounded by walls, which need not necessarily be more than 8 feet high.

Regimental Barrack.

Artillery.

The organisation of the Artillery is different from that of the rest of the army, and, being also different and variable in itself, makes it difficult to arrange a normal barrack for them, corresponding to that for the cavalry and infantry. There are three branches of the artillery service: 1st. The Horse Artillery. 2nd. The Field Batteries. 3rd. The Garrison Artillery. It is not, however, necessary for our present purpose to include the latter, as they are only required in fortresses where the barrack accommodation forms part of the plan of the work. And, as the field batteries form by far the largest part of the artillery, the requirements for them should form the basis for their barrack arrangements.

The unit of administration in the British Artillery is the battery of six guns; and the ordinary peace establishment of a field battery is six officers, 11 sergeants, 203 gunners and drivers, 17 carriages (including the six guns), and 104 troop horses (including six for the officers).

The captain of a battery is responsible for the efficiency, equipment, clothing, pay, messing, and forage of the whole battery; he receives the pay, clothing, and equipment direct from the War Department, and the rations and forage direct from the contractor; his command is therefore that of a small regiment, and the barrack of a battery should therefore have an arrangement complete in itself.

The battery is divided into three divisions of two guns each, with a subaltern in command of each, who commands it on parade, and exercises nearly the same administrative functions over it as the captain of a troop or company; the whole force of the battery, men, guns, carriages, and horses, being told off to the three divisions. It is, therefore, further desirable to arrange the barrack accommodation by divisions.

Deducting the officers, and 8 per cent. for married men, there remain 11 sergeants and 187 rank and file to be provided for.

Adopting the separate system, three of the units of infantry company quarter would accommodate the above numbers, leaving the space of 40 men (or about two rooms of 18 men) for the battery store room and collar-makers' and tailors' shops, and a sergeant's room for an orderly room.

Three of the units of troop stable above described would hold all the horses, and (if the stalls were all built expressly with a view to this arrangement), by removing the fitments, would also provide harness rooms and gun sheds and officers' stalls, leaving about 20 spare stalls. Each stable would be occupied by a division, and in each 16 troop stalls would be required for the guns and waggons of the division, and four officers' stalls for the harness. The gun and limber, from muzzle to point of shaft, occupy a space 25 feet long and 7 feet wide; two guns and a waggon could stand in a breadth of 20 feet; and there are two guns and four waggons in a division. A double set of harness (riding and pack), as they are generally hung, occupies about 3 feet of wall lineal, and there are 14 double sets in a division. Thus one unit of barrack and one unit of stable would hold the division, the guns, horses, and harness being under one roof; and three such units of barrack and stable would hold the battery complete, except the farriers' and wheelers' shops.

The Staff Buildings.—One room is required for every battery as an orderly room for the accounts and records; and one room, at least 30 feet by 20 feet, for the quartermaster-sergeant's store room, in which he has to keep the stock of stores and implements, as well as appointments and clothing of the battery. The collar-makers' and tailors' shops may adjoin, and require together about the same space as the store room. The farriers' shop requires space for two fires and a small veterinary surgery, and the wheelers' shop requires about 20 feet by 15 feet; these two shops should be together, and in a position corresponding to that of the farriers' shop in a cavalry regiment.

The forage barn should also be in a position corresponding to that of the cavalry regiment, and upon the same plan, though only about one-third the size.

The plan of a normal artillery barrack (Plate II.) illustrates the requirements for an artillery barrack of two batteries, one-half on the separate system, according to the arrangement above described, and one-half on the combined system, in which one unit of combined troop quarter accommodates the division of a battery, men, guns, horses, and harness, or three units of combined troop quarter accommodate the battery complete, except only farriers' and wheelers' shops.

In the centre of the two batteries would be required a small staff building for the *commanding officer of the brigade*, who, being purely a staff officer, requires accommodation only for his own office and that of his clerks.

The buildings are placed at right angles to the general front, and at 60 feet clear interval, which would allow space for each division to hook in opposite that part of the stable appropriated as a gun-shed. This arrangement most nearly accords with the best plan of an artillery camp, when the guns and carriages are parked in front ready for action, and the men and horses and harness stand by sub-divisions at right angles to the

front, and the officers are in a line in rear of them. The field battery in line occupies a frontage of 400 feet (allowing 19 yards per gun and 19 yards on each flank for wheeling), and about 140 feet deep (on the peace establishment).

Horse Artillery.—The battery of horse artillery has the same organization as the field battery, and the same establishment of men, guns, and carriages, but with six officers' horses and 102 troop horses in addition; therefore, as far as the men are concerned, the same unit of quarter will accommodate them; and, in order to carry out the same principle of quartering by divisions, the unit of troop stable proposed for the cavalry branch should be appropriated entirely to troop horses and harness, by which the three units will hold all the horses and all the harness; and the guns, carriages, and officers' horses should be placed in a stable specially arranged for the purpose, in rear of the staff building, on the site and in the manner proposed for the staff stable in a cavalry regiment.

Officers' Quarters.—The position of the officers' quarters in the regimental barrack having been already discussed, the interior arrangement only remains for consideration; and the chief point that appears desirable to be attained is, that they shall be so simple and uniform as to be applicable to a very small as well as a very large number of officers and to all classes, and to such other military purposes as living-houses are frequently appropriated in our service, in fact, to have a unit of the officers' quarters. The smallest number of officers that we need take into consideration consists of the three officers of a company, the captain and two subalterns; wherever a company is stationed, at least these three officers must be provided for with it, and the simplest and most obvious plan of housing them appears to be in a small house of three floors, having an officer on each floor, so that as many such houses as may be necessary may be put together for a regiment or battery.

The only regulation concerning the sizes of officers' quarters is, that a commanding officer shall have two sitting rooms, two bed rooms, and two servants' rooms; and any other field officer two rooms and one servant's room. The other officers of the army are only entitled, according to the custom of the service, to one room and a share of a servant's room. The synopsis recommends three sizes of rooms—16 feet by 18 feet, 16 feet by 16 feet, and 16 feet by 14 feet. These sizes appear to be, on the whole, large. It is a disadvantage to an officer to have too large a room to furnish and warm and keep clean. The unit shown in the plan of the normal regimental barrack has two rooms on each floor: those on the ground floor are 13 feet by 14 feet and 11 feet by 16 feet for two servants; those on the two upper floors are 18 feet by 13 feet and 11 feet by 16 feet for the captain and two subalterns. The areas of two of these rooms are rather more than those of one room and a-half 16 feet square, as proposed in the synopsis.

One such unit would form a regulation quarter for two field officers, or for the commanding officer; and for the regiment of infantry there would be required 14 such units, for the regiment of cavalry 12, and for the battery of artillery two.

Mess Establishment.—it is more important, considering the system of our service, to have a good mess establishment than to enlarge the

officers' quarters; for it is, or it should be, the place of common resort and meeting of the officers at all times; it should contain a dining-room large enough to dine 50 persons occasionally, and 30 daily; 45 feet by 25 feet is sufficient for this purpose: too large a room could not be made comfortable, and would defeat its object. A comfortable ante-room, where the officers can sit during the day and read papers and periodicals, forms a very important part of the establishment; a long room about 25 feet by 15 feet would be most convenient for it. The establishment should also include kitchen, store-rooms, messman's rooms, forming a distinct branch from the cellars and pantry and butler's room. Altogether the mess establishment is one of so much importance, and so special in its requirements, that it is impossible to include it in any general classification of buildings; it should form a complete building standing by itself, like the hall of a college, and would, if well designed in this manner, not only be more useful, but more ornamental, than if merely fitted into a general block of officers' quarters.

General Remarks.

The subject and object of this paper may therefore be briefly recapitulated to be, "The arrangement and construction of barracks, with a view to lay down some general principles for the arrangement of, and to determine a few simple forms of construction applicable to, all barrack buildings."

The principles of arrangement proposed are based on the three great considerations ruling the whole question, Defence, Administration, and Health; and, while allowing that the perfectness of any one of these three will not compensate for a serious deficiency in any one of the others, I have simply sought to point out some of the necessary requirements of each, believing that in most cases a due consideration of the values of these respective requirements will produce a more harmonious result than would at first be supposed, and that it is at least the only true way of treating the question.

The forms of buildings which I arrive at from these considerations as most simple and generally applicable are the following:

1. *The unit of company quarter*, which, without material alteration, is applicable to infantry, cavalry, and artillery, and to variable numbers, and to married soldiers' quarters, and includes all the purely company requirements.

2. *The unit of stable*, which, without material alteration, is applicable to a troop of cavalry or a battery of artillery, and includes the whole of the horses and appointments, officers and troop, and guns and carriages of a troop or divisions of a battery.

3. *The unit of officers' quarter*, applicable, without any alteration, to officers of all ranks, and to the proportions of each rank in a regiment or to one company, and applicable also to offices.

4. *The unit of storehouse*, or rather normal storehouse, applicable to all stores, regimental or departmental, quartermaster's, barrack, commissariat, or military storekeepers.

The above include all the principal military buildings, which are thus classed into four groups,—barrack, stalls, officers' quarter, and storehouse; of the remaining buildings of a military station, such as the chapel, cook-

house, washhouse, messhouse, schoolhouse, canteen, library, reading or day room, gymnasium, ball-court, prison, it appears hardly possible to classify any two together, either on account of their special requirements or from the uncertainty of the demand for them. The hospitals also form a special group of themselves. But in any or in all military buildings it would be advantageous to have as far as possible only one span of roof, for facility both of construction and repair, and of alteration and re-appropriation.

I think it will be generally allowed, that, in a variable service such as the British army has to perform, every discussion upon military buildings that tends to produce simplicity, uniformity, and flexibility, will also tend to the security, efficiency, and health of the army generally.

The Chairman: I think Colonel Collinson has given us a most useful and practical paper. He has reduced a very complicated and difficult question into a practical form, one which must be extremely conducive to the three objects which he has pointed out: the first, capability of defence; the second, sanitary conditions; and the third, the general comfort of the soldier.

It is an extremely agreeable thing to me, when I look back for about eight years, to find this question so taken up by an officer of Colonel Collinson's standing, and also to see the way in which it has been taken up in recent times by the War Department. The whole of the improvements in barrack accommodation are limited to a period of eight years. They were begun in the year 1854, and they were begun by the present Lord Dalhousie, then Lord Panmure, Secretary-at-War at that time. He appointed a Committee, upon which I had the honour to serve in conjunction with my friend Major White. That Committee was appointed in consequence of the constant observations made in the House of Commons in regard to the deficiency of barrack accommodation, and also in consequence of the frequent representations which were made by various commanding officers to the Horse Guards. Lord Panmure was the first person to move in it. Although I believe that Committee did very great good in pointing out the evils which were attendant upon the barrack accommodation then in existence, yet I am sorry to say the Committee did not accomplish much more, for at that time the feeling in favour of the British soldier had not risen to that fever-heat to which it rose two years afterwards in consequence of the Crimean war. The feeling in favour of the soldier then rose to such an extent, that I believe you could have got any amount of money expended for his benefit. From that time to the present, improvements have been effected which have been most beneficial to him.

You cannot compare the position of the British army with the position of any other army in the world. It stands entirely by itself. Take the French. The Frenchman must be a soldier whether he likes it or not; he has not any option. He can pay a large sum for a substitute, but, as a general rule, he has not got the option whether he will serve or not. And, when enlisted, they give him hardly any pay at all. Everything is found for him, and he must stay in the army until he has fulfilled his seven years' service.

The British soldier on the contrary is a free agent before he enlists.

You cannot compel him to enlist. You give him inducements to do so, but he rarely enlists because he has an affection for the military service. Perhaps he does it in consequence of some scrape he has got into in his village, or because he wishes to join some comrade; rarely in consequence of any great wish to lead a military life. Therefore, our great object has ever been, when we have got him, to make him comfortable as soon as he becomes a soldier. Perhaps at the present moment we are not able to do that to the full extent, but at any rate he is in an incomparably better position than he was eight years ago, and in an infinitely better position than he was when I first entered the service. One of the first things done, has been to take spirits out of his way. Formerly the soldier had nothing to do but to walk out of the barrack room into the spirit shop. There were schools, but schools of an inferior character. They have been very much improved, but barrack building has to be found for these. Libraries are only a recent creation, of perhaps twenty years; barrack building must be found for them. Formerly eighteen or twenty men were crammed into a room with only two or three hundred cubic feet of air, now they are to have six hundred; increased barrack building has to be found for this. So I might go through a long catalogue of improvements which are being made, all tending to the advantage of the soldier, and all consequent I believe upon the movements which have been made, particularly by the officers. I quite acknowledge that these improvements have been carried out by civilians, but those civilians have been prominent men at the head of public departments, without whom we, as soldiers, never could have carried them out. Therefore, I do not mean to deprive them of the full credit of having more than met us half way, and of having done our work for us, because all we could do was to point out the deficiencies which existed, and, having pointed them out, to take advantage of the state of public feeling which gave the opportunity for benefiting the great military branch of the public service.

In offering to Colonel Collinson our thanks for the paper he has read, I can only say that I hope his labours will be conducive to the good of the army.

Evening Meeting.

Monday, March 17th, 1862.

W. STIRLING LACON, Esq., Member of Council, in the Chair.

THE WAR IN NEW ZEALAND.

By CAPTAIN PASLEY, R.E.

PART I.

THE CHAIRMAN: I have great pleasure in introducing Captain Pasley of the Royal Engineers, who is about to read a paper upon the War in New Zealand. Captain Pasley served in New Zealand during the war, and was wounded in one of the actions.

CAPTAIN PASLEY: Mr. Chairman, Ladies, and Gentlemen,—In order to make the remarks which I have to offer upon the war which has recently taken place in New Zealand intelligible to those amongst you who are not well acquainted with that colony, it will be necessary to give in as few words as possible a sketch of the previous history of the country.

New Zealand consists of two large and a number of smaller islands. The northern island, which contains nearly the whole of the aboriginal or Maori race, is considerably larger than Ireland. The other large island is about the size of England and Wales. The first European navigator who as far as we are aware ever visited New Zealand, was Tasman, who touched there in 1642. Captain Cook, who visited the islands in 1769, left behind him a permanent record of his presence, in the shape of pigs and potatoes, then for the first time introduced into the country. These gifts were of the greatest value to the people of a country in which indigenous animals and edible vegetables were very scarce. For many years subsequently to Captain Cook's voyage no attention was paid to the islands, but towards the close of the last century New Zealand began to attract notice in England, America, and Australia, as a favourable station for whaling. A large number of vessels was sent from those countries to cruise about New Zealand in search of whales, and depôts of stores and provisions were established on the coast, the most important of which was Kororareka, in the Bay of Islands.

The natives gladly welcomed these settlers, who in the course of trade supplied them with many things, the value of which they readily learnt to appreciate. In all their dealings they showed an aptitude for improvement and civilisation which has been rarely observed among savage tribes. They cared nothing for coloured beads and trinkets, but iron in every shape found a ready sale amongst them. Blankets and tobacco were also great articles of trade, and soon became almost necessaries of life to them. Constant intercourse with Europeans soon created in the minds of the

more enterprising of the Maories a desire to see foreign countries, and in 1820, Hongi, the principal Chief of the Ngapuhi tribe, made a voyage to England, where he was received with much honour, and introduced to King George IV. Up to this period the Maories had been entirely unprovided with fire-arms, but Hongi, on his return to New Zealand, procured 300 muskets, with which, having armed a portion of his followers, he commenced a career of war and conquest which spread desolation over the country for several years. His contact with civilisation in England does not appear to have done much towards refining his tastes, for, not content with slaughtering his enemies, he cooked and ate as many of them as he could. Traditions differ very much with regard to the origin of cannibalism in New Zealand, but it is supposed to have been first practised as an act of vengeance. There does not seem to be any reason to suppose that the Maories ever devoured human flesh merely for the purpose of satisfying their hunger. The practice was always connected in their minds with the idea of insult, triumph, or revenge. No Maori could offer a more deadly affront to another than to tell him that his father had been eaten. After every battle the prisoners were triumphantly devoured. Thus, war promoted cannibalism, and cannibalism promoted war.

The first result of Hongi's wars was a great demand among the Maories for fire-arms, the possession of which had become essential to the safety of each tribe. This demand gave a great stimulus to trade, and consequently to agriculture and other industrial pursuits. From this again arose a desire and demand for other European manufactures, such as clothing, cooking utensils, and agricultural implements. Notwithstanding these advances towards civilisation, petty wars and feuds raged for many years more violently than ever among the various tribes, to whom the possession of new and more formidable means of destruction appeared to have imparted a fresh desire for blood.

In the meantime the European settlers at various points on the sea-coast had been rapidly increasing in numbers. In 1838 the population of Kororareka amounted to not less than 1,000 souls, chiefly whalers, sealers, runaway sailors, and escaped convicts. These persons were under no recognised or lawful government whatever. The native chiefs did not wish or attempt to exercise any control over them, and no civilised power had as yet claimed any sovereignty over the island. The state of anarchy and lawlessness into which the settlement consequently fell soon became intolerable to the inhabitants themselves, who attempted to put a check upon it by the establishment of an institution somewhat similar to the famous Vigilance Committees of the United States.

In 1839 immigrants of a different character began to arrive, under the auspices of the New Zealand Company, by whom systematic colonization on a great scale was attempted.

Colonel Wakefield, the leader of the expedition, purchased an immense territory from the natives, on payment of goods valued at about 9,000*l.* It appears very doubtful, however, whether the natives understood the real nature of the bargain they were making, or that they ever intended to part with the fee-simple of the land. It had been an immemorial custom among them for tribes, families, or individuals, to make over land to others for temporary purposes, but the right of resumption was always

reserved, and they probably had no idea of the real nature of the claim which the agent of the New Zealand Company was endeavouring to establish upon them. The formation of the New Zealand Company's settlement at Port Nicholson, together with the scandal caused by the lawlessness of the people of Kororareka and other whaling stations, at length compelled the British Government very reluctantly to interfere, and in 1840 Captain Hobson was sent to the Bay of Islands, as first Governor of New Zealand.

In the same year the well-known treaty of Waitangi, by which the great majority of the Maori chiefs ceded to Her Majesty the sovereignty of the islands, was concluded. One of Governor Hobson's first acts was the issue of a proclamation declaring that all future purchases of land from the natives, without the intervention of the Crown, should be illegal, and that the validity of all purchases already effected should be investigated, and Crown grants issued for such as might be proved to have been obtained for fair consideration.

The result of the investigation was that the great majority of Colonel Wakefield's purchases were annulled.

In the mean time a revolution of another kind had been going on in the country. The first missionaries of the Church of England arrived in the country in 1814, under a promise of protection from the great chief Hongi, a promise which, although not himself a convert, he faithfully kept.

They were followed by Wesleyan missionaries in 1822, and by Roman Catholics in 1838. The result of their labours has been very remarkable. I believe that at the present day at least three-fourths of the Maori race are baptized Christians, and professing members of one or other of these three denominations, and the great majority of the remainder can scarcely be called heathens, as, although not baptized, most of them attend church and school. Slavery and cannibalism have disappeared from the land as Christianity has taken root among the people. The eminently practical character of the native mind, which was evinced in the first instance by their preference for iron over the baubles which generally charm savages, had indirectly an important influence on the promotion of Christianity. The missionaries established not only churches, but schools, where children and adults were taught to read aud write in their native tongue. The Maories at once appreciated the immense value of the art of writing, and were thus induced in large numbers to attend the schools, where they were also instructed in the truths of religion. They were thus gradually converted to Christianity, and, as far as it is possible to judge from outward appearances, they seem to be quite as good Christians as the average of Europeans.

It was estimated a few years ago that one-half of the native population of New Zealand belonged to the Church of England, one-fourth to the Wesleyan and Roman Catholic communions, and one-fourth unbaptized, although not necessarily or generally heathens.

At the period of the establishment of the British Government in New Zealand the northern tribes carried on a considerable trade, not only with the settlers of Kororareka, but with the Australian colonies, in which there was a great demand for Hokianga timber. Between 1840 and 1844 the prosperity and wealth of these tribes were greatly diminished owing to various causes, of which the most important were the cessation of the

demand for timber in Australia, the removal of the seat of government from Kororareka to Auckland, and the establishment of customs duties, which interfered with the irregular but profitable trade previously carried on.

A strong dislike to the British Government consequently sprang up in the minds of many of the natives.

Heke, a Ngapuhi chief, who owing to his marriage with the daughter of Hongi had become one of the most influential men in his tribe, took advantage of this feeling, and persuaded a large number of the people that their losses were owing to British supremacy alone. As a practical illustration of this opinion, he and his followers cut down and burnt the flag-staff at Kororareka. He was soon afterwards persuaded to offer an apology to the Government, and the flag-staff was re-erected, but again destroyed by Heke, who apparently attached some mysterious importance to that symbol of sovereignty. A new flag-staff sheathed with iron was then put up and placed under the protection of a detachment of troops. A small body of seamen, with a gun from H. M. ship "Hazard," were also stationed near it.

In March 1845 Heke attacked the town, of which he obtained possession after a skirmish, which resulted in the embarkation of all the inhabitants and the destruction of the town by fire.

Nothing like a savage or bloodthirsty disposition was evinced by the Maories on this occasion. On the contrary they restored uninjured to their parents a number of children who had been left behind in the hurry of the flight.

Reinforcements having arrived from Sydney, a force was despatched from Auckland to the Bay of Islands on the 3rd of April under the command of Colonel Hulme. It was ascertained that Heke had established himself at a pa called Okaihau, 18 miles inland. The British force consisted of about 400 men, and was joined by an equal number of native allies under Waka Nene another Ngapuhi chief, who has always to this day proved himself a firm friend of the colonists. The expedition carried a few rockets but no guns. The weather being exceedingly unfavourable, and the troops having to carry their own provisions as well as ammunition, four days were consumed in making their way to the pa.

So little was known at that period of the character of these peculiar works of defence, that Colonel Hulme contemplated taking the pa by assault without having previously effected a breach, but he wisely allowed himself to be dissuaded from making the attempt by Waka Nene, who urged him not to sacrifice his men in a mad and impossible enterprise.

The Maories, emboldened by the hesitation of the attack, made a sortie, but were at once repulsed at the point of the bayonet by the 58th Regiment and the Marines. Colonel Hulme, seeing clearly that without artillery he had no chance of success, marched back to the coast and re-embarked his troops, having lost during the operations 14 killed and 39 wounded.

Experience having now shown that the employment of artillery was necessary for the reduction of a strong pa, a second expedition was fitted out for the attack of a new pa which Heke had built at Oheawai, 7 miles inland from Waimate. The force consisted of 630 troops, seamen, &c., with 6 guns, under the command of Colonel Despard, and 250 Maori

allies. The garrison of the pa was estimated at 250 men. The expedition arrived at Oheawai on the evening of the 23rd June, and on the following morning the guns commenced firing on the pa without result. Afterwards a thirty-two pounder was brought up, the fire of which produced so much effect upon the stockade, as to induce Colonel Despard (in opposition to the opinion of Captain Marlow, R.E., who did not consider the breach practicable) to risk an assault. A storming party was therefore told off, consisting of 200 soldiers, seamen, and volunteers, with hatchets, ropes, and ladders. The attempt was most gallantly made, but in a few minutes the troops were compelled to retire, leaving one-half their number killed or wounded at the foot of the stockade.

The enemy, safely esconced in their rifle pits, watched with mingled feelings of admiration and compassion the steady advance of the storming party to certain destruction, whilst our native allies made no secret of the indignation they felt at the useless sacrifice of the lives of so many brave men.

For several days subsequently, no movement took place on either side. On the 9th of July, fire was again opened on the pa, which on the 11th was discovered to have been abandoned by the enemy. On the 14th the troops returned to Waimate.

Both parties claimed the victory, and both with some appearance of reason. The troops claimed it on the ground that they had compelled the enemy to evacuate a strong position. The Maories claimed it, because, being opposed to a number far greater than their own, they had lost but few men, and killed and wounded a great number of their opponents. Such a result in their eyes constitutes a victory, and when we consider the rapidity and facility with which they are able to erect their pas, and the abundance of strong and commanding positions throughout their country, which makes the loss of a pa of very trifling importance to them, it must be acknowledged that they had the best of the argument.

An expedition on a larger scale was dispatched a few months afterwards against Ruapekapeka, a larger and stronger pa than either of those which had been previously attacked.

It was situated about sixteen miles inland from Kororareka, and contained a garrison of about 500 men under Kawiti, a friend and ally of Heke. The expedition consisted of 1,110 Europeans (including 280 officers and men of the navy) and 450 natives, with three 32-pounders, one 18-pounder, a few field guns, and some rockets. They arrived in front of the pa on the 31st of December. On the 2nd of January, 1846, the enemy made a sortie, which was repulsed by the friendly natives. On the 10th of January the guns, having been placed in position, opened fire. They fired all day on the pa, and succeeded in making two small breaches in the outer stockade. The following day being Sunday, the enemy, expecting a suspension of hostilities on that day, retired to the rear of the pa to cook their food and to carry on their devotions. Some of the friendly natives having crept up to the stockade and ascertained that it was deserted, beckoned to the troops to advance. A party of the 58th and some sailors at once entered the pa and established themselves there. The enemy, as soon as they became aware of the unexpected entrance of the troops into the pa, made gallant and repeated attempts to dislodge

them, but in vain. Reinforcements poured in and the Maories were compelled to retreat.*

The natives were now beginning to get tired of the war, which materially interfered with their comforts by stopping their supplies of tobacco, blankets, and other articles, to which they had become so much accustomed as to be hardly able to dispense with them.

Heke's predictions of the renewed prosperity which was to be the result of the war were so far from being fulfilled, that the poverty and misery of the natives increased every day.

Heke and Kawiti consequently soon found themselves almost without followers, and were compelled to sue for peace, which they readily obtained, with a full amnesty from the Governor.

In the same year hostilities broke out at Wellington (Port Nicholson). After several skirmishes, in which the natives were generally the assailants, they were forced by starvation to retire from the district. They removed to Wanganui, and succeeded in the following year in exciting the natives of that district to make war against the Europeans.

On the 19th May, 1847, about 600 Maories attacked the town of Wanganui, where 170 soldiers were stationed in small stockades. A heavy fire was kept up on both sides during the day. In the night the enemy plundered the town and departed. Hostilities were carried on during two months with varying fortune, and on the 23rd July the enemy sent a flag of truce and announced that they were now for peace, "being satisfied with the number of soldiers slain."

The effect produced upon the minds of the Maories by these hostilities was highly gratifying to their self-love. They were, it is true, profoundly impressed by the magnitude of the resources of England, as evinced by the constant stream of reinforcements which poured into the country, owing to which the available number of troops was, notwithstanding their losses, continually on the increase, and they felt the hopelessness of final victory in a contest with a power which became stronger after every disaster. Nevertheless, the ill-success which had attended most of the military operations led them to think themselves very superior to the troops, both in military skill and in personal prowess.

They acknowledged, indeed, that the superior arms and discipline of the troops rendered them very formidable in the open country; but they were in the habit of boasting, that, whenever war might break out again, they would draw the soldiers into the forest, where they would be able to do what they liked with them. Such being their opinion, it is not surprising that many of their young men should have been eager to take advantage of any opportunity of enjoying the excitement and gaining the honour which they confidently expected to follow a collision with the troops.

Although the peace was not actually again broken between the two

* The labour and hardships endured by the troops in advancing and retreating even a very few miles through the forest were excessive, and the cheerfulness, patience, and fortitude with which they were borne, beyond all praise. Had the enemy been somewhat more numerous, and as energetic as the present generation of Maories have proved themselves to be, these expeditions would, in all probability, have shared the fate of that of General Braddock in North America. Perhaps their unmolested retreat may have been due to the presence of the native allies, who, although they did not over-exert themselves either in working or fighting, were invaluable as guides and scouts.

races until the year 1860, signs of coming discord were visible as far back as 1854, in which year some of the chiefs of the Waikato tribe, the most powerful and warlike in the country, alarmed at the increasing numbers and power of the colonists, conceived the project of setting up a king of their own; their principal object being to put a check upon colonization, by preventing the further alienation of land. The history of this movement and its connection with the war which has recently taken place at Taranaki are clearly and succinctly described in the following extract from a memorandum drawn up by the minister for native affairs at Auckland, in April, 1860.

That the present crisis in the affairs of New Zealand may be properly understood, it is in the first place requisite to give some account of the views and intentions of the native agitators known in the colony as the Maori or Waikato King party. The contest in Taranaki between the British Government and the chief Wiremu Kingi and his followers derives all its importance from its connection with this movement, for without the sympathy and expected support of the Waikato league the Taranaki natives would never have ventured upon armed resistance to the British Government.

The first proposal for the erection of a separate native state under the Waikato chief Te Whero Whero (now generally called Potatau) seems to have been made as far back as 1854. There was at first considerable diversity of opinion amongst the promoters of the movement, and great consequent uncertainty as to its precise objects. Many well-disposed natives seem to have joined in it without any thought of disaffection towards the British Government, and purely, or principally, with a view to establish some more powerful control over the disorders of their race than the Colonial Government has found it possible to attempt. But there are others whose objects have been, from the beginning, less loyal. These men have viewed with extreme jealousy the extension of the settled territory and the increase of the European population. Various influences have combined to augment the effect on their minds of this natural feeling. The lower class of settlers, sometimes wantonly, sometimes under provocation, have held out threats of a coming time when the whole race will be reduced to a servile condition. Of late, a degraded portion of the newspaper press has teemed with menaces of this kind, and with scurrilous abuse of the natives, and all who take an interest in their welfare. False notions respecting the purposes of the British authorities have been industriously spread by Europeans inimical to the Government, and whose traitorous counsels enable them to maintain a lucrative influence over their credulous native clients; and there may have been some few honest friends of the Maories, who, looking only to the better side of the agitation, have given countenance to a movement which, in their opinion, promised to promote the establishment of law and order, and the advance of civilization, and to afford a beneficial stimulus to the languishing energy of the Maori people.

The Government at one time entertained a hope—a hope now deferred, but not abandoned—that the good elements in the King movement might gain the ascendancy, and become the means of raising the native population in the social scale. It must, however, be admitted that the agitation has of late assumed a most dangerous phase.

The two objects of the league may now be affirmed to be, first, the subversion of the Queen's sovereignty over the northern island of New Zealand, and, secondly, the prohibition of all further alienation of territory to the Crown.

As regards the first object, the more advanced partisans of the Maori king now distinctly declare that the Queen of England may, for aught they know, be a great sovereign in her own country, but that here, in New Zealand, she shall become subordinate to their native monarch, from whom the British Governor shall take his instructions. The utmost conceded to the Queen is an equal standing with King Potatau.

The absolute prohibition of further land sales is a necessary part of the new policy; for it is plainly seen that, unless the further colonisation of the country can be put a stop to, the Europeans will shortly outnumber the natives even in the northern provinces.

The general sentiment of the New Zealanders with respect to their territorial possessions entirely harmonises with the views of the king-makers. The Maori feels keenly the parting with his rights over the lands of his ancestors. The expressive words of the deeds of cession declare that under the bright sun of the day of sale he has wept over and bidden adieu to the territory which he cedes to the Queen. It is in vain to

assure him that the land remains open to him upon the same terms as to the European settler. He cannot see the matter in this light. The soil, with all its memories and the dignity conferred by its possession, have passed over to the stranger; and in its place he has acquired only perishable goods, or money which is speedily dissipated. The land-holding policy of the King party is popular, because it secures to every native the occupation, in savage independence, of extensive tracts of wild land.

When the first emigrant ships arrived at Port Nicholson, and landed their hundreds of colonists, the natives are said to have wept at the sight. They had been told, but had not believed, that the foreigners were coming to settle in great numbers upon the land which the agent of the colonising Company had just acquired. They had not realised to themselves that their country was about to be occupied by a civilised race in such force as to be able to hold its ground in spite of native resistance. The New Zealanders had always been fond of having amongst them a few Europeans dependent on their goodwill, but they love to remain masters. It is the notion of the King party that the settlers in New Zealand should be placed much on the same footing as the European squatter in a native village, whose knowledge and mechanical skill procure for him a certain amount of respect and influence, but whose homestead is held on sufferance, and who is obliged to comport himself accordingly. "Send away the Governor and the soldiers," they say, "and we will take care of the Pakehas."

The old chief, Te Whero Whero, who has been a firm ally of the British Government, has been removed by his relatives of the new faction from his late residence at Mangere near Auckland to a place called Ngaruawahia, at the confluence of the Waikato with its principal feeder the Waipa. There his supporters have established the old man (who seems to lend himself unwillingly to the farce) in a kind of regal state. The deputation despatched from Taranaki to solicit support for W. Kingi were clothed for the occasion in a uniform dress. They approached in military order. At a given signal all fell on their knees, whilst some one in a loud voice recited the text "Love the Brotherhood. Fear God. Honour the King!" After the interview the deputation retired, facing towards the royal presence. They appear to have been well drilled in this ceremonial.

The absurdity of these pretensions does not render them less dangerous. Unfortunately they are supported in the minds of the natives by an overweening opinion of their own warlike skill and resources. It must be confessed that the imperfect success of military operations in New Zealand has given some countenance to the natives' fixed opinion of their own superiority. In the debates of the Maori council at Ngaruawahia, the experience of the wars against Heki and Rangihaeata, and of the Wanganui war, are constantly referred to as showing how little is to be feared from the prowess and the boasted warlike appliances of the Pakeha.

As regards the further alienation of territory, the received interpretation of the treaty of Waitangi recognises rights in the native proprietor which must be respected, however inconvenient those rights may prove; but it would not be politic, or safe, or right, to submit to the attempted usurpation of a power of obstructing the settlement of the country which the admitted interpretation will not warrant. The treaty secures to the native proprietor the right to part with to the Crown, or to retain for himself, lands which are his own. The King party would assert a national property in or sovereign right over the remaining native territory, and are ready to support all opposition to land sales, without nice inquiry respecting, and even without reference to, the merits of each particular case. In this they infringe at once upon the rights of the Crown and of the native proprietor.

It is by no means meant to assert that all who have joined or who favour the party of the Maori King propose to themselves ends so dangerous and unjustifiable. Potatau himself is probably sincerely averse to any proceedings hostile to the Government. It is, however, uncertain how far he may have power to restrain his people, and it is undeniable that sentiments quite as strong as those above described are freely expressed throughout the districts south of Auckland, and may be expected to shape the action of a large part of the powerful tribes of Waikato.

Such then is the party to whom William King of Waitara is looking for support, and, it is to be feared, with some prospect of success; and it now becomes necessary to give some explanation of the origin of the present disturbances at Taranaki.

The settlement of New Plymouth was founded in 1841 by the Plymouth Company of New Zealand, which subsequently merged in the New Zealand Company. There were at that time scarcely any natives in the district. Some had fled southward to Cook's Straits, to avoid the invading Waikatos. Many others, who had been captured on the

storming of the Ngatiawa stronghold Pukerangiora, still remained slaves in the Waikato country. The New Zealand Company's agent had purchased of the resident natives, with the assent of some of their relatives at Port Nicholson and Queen Charlotte's Sound, a tract of country extending from the Sugar Loaf Islands to a place called Taniwa, between three and four miles north of the Waitara River. The block extended about fifteen miles along the coast, and contained 60,000 acres. It included the land now the subject of dispute. After the arrival of the settlers, the refugee Ngatiawas and manumitted slaves from Waikato began to return in great numbers, and disputed possession of the block with the settlers. So completely, however, was the Waikato right of conquest admitted, that their permission was sought and obtained by the returning Ngatiawas before they ventured to set foot in the district. The Waikato had, however, previously transferred their rights to the British Government by the deed of cession which will be presently referred to.

In 1844 the Land Claims Commissioner, Mr. Spain, investigated the New Zealand Company's title, and reported in favour of their purchase; but Governor Fitzroy took a different view of the rights of the absent and enslaved Ngatiawa, and refused to confirm Mr. Spain's award.

In consideration of an additional payment, the returned natives consented to surrender a small block of 3,500 acres, comprising the town site; and within these narrow limits the British settlement was for some time confined. Other small blocks were subsequently from time to time acquired, and the settlement now extends for a distance along the coast of about five miles in each direction, north and south, from the town. The European population amounts to upwards of 2,500 souls, greatly outnumbering the resident natives.

The northern boundary of the settlement is little more than four miles from Waitara; but on this side of the town the Crown lands are intermixed with territory over which the native title has not been extinguished. A singular spectacle is here presented of peaceful English homesteads alternating with fortified pas, which command the road to the town at many points, unpleasantly reminding the spectator that the savage law of might still rules in this fair district.

It need scarcely be said that the occupants of these pas do not regard themselves, and practically are not, amenable to British jurisdiction. Since 1854 they have been in continual feud amongst themselves, and there has been a succession of battles and of murders in close proximity to the settled territory. A chief has been slaughtered on the Bell block; skirmishing natives have sought cover behind the hedgerows, and balls fired in an encounter have struck the roof of a settler's house.

These feuds have arisen out of disputes as to the title of land. One native faction has been steadfastly opposed to the alienation of territory to the Crown; the other party has been not less passionately determined to sell, and the contest has been as to their right to do so. The sellers naturally carry with them the sympathy of the colonists, who feel that an extension of the settlement would bring, not simply a material prosperity which this unfortunate place has never known, but also the far greater blessings of peace, security, and the prevalence of British law.

It is obvious that in such a state of things the relations of the two races thus closely intermixed must be full of peril. The embarrassment to the Government is extreme. But without some knowledge of the native character its extent will not be fully apprehended. When a native has offered to cede land to the Crown, his pride (perhaps the strongest passion of a chief) is committed to carry the sale into effect against all opposition, and it may be equally dangerous to the peace of the country to accept or refuse the offer. If the offer be accepted, the Government becomes involved in difficulties with the opposing party; if refused, the seller will seek to revenge himself upon his opponent, or become disaffected towards the Government that has put a slight upon him. If his passion does not turn in either of these directions, he will probably persevere in his attempts to induce the Governor to purchase; thus keeping open a source of agitation and peril. Taranaki is by no means the sole seat of such difficulties. At the present juncture in the affairs of the colony the Government is in other quarters placed in a similar dilemma, and is in the greatest danger of alienating those chiefs who are friendly by the rigid scrutiny to which it is requisite to subject their offers of land. The truest policy would be a fearless administration of justice between the contending parties. Unfortunately to determine absolutely what is just is often impossible in these cases, and were this otherwise the British Government is not in a position to enforce its award.

In March, 1859, the present Governor visited New Plymouth, and on the 8th of that month held a public meeting of all the principal chiefs of the district, the native secretary, Mr. McLean, acting as interpreter. The proceedings had reference to the establishment of British law throughout the Taranaki district, and in the course of his address the Governor said, "he thought the Maories would be wise to sell the land they could not use themselves, as what they retained would then become more valuable than the whole had previously been. He never would consent to buy land without an undisputed title. He would not permit any one to interfere in the sale of land unless he owned part of it; on the other hand, he would buy no man's land without his consent."

Immediately after this declaration by the Governor, a Waitara native, named Teira, stepped forward, and, speaking for himself and a considerable party of natives owning land at Waitara, declared that he was desirous of ceding a block at the mouth of the river on the south bank. He minutely described the boundaries of the block, stating that the claims of himself and his party went beyond those limits, but that he purposely confined his offer to what indisputably belonged to himself and his friends. Being a man of standing, and his offer unexpected by many present, he was listened to with the greatest attention, and concluded by inquiring if the Governor would buy his land. Mr. McLean replied that the Governor accepted the offer conditionally on Teira's making out his title. Te Teira then advanced and laid a native mat at the Governor's feet, thereby symbolically placing his land at his Excellency's disposal. Teira's right was denied by none except a native named Paora, who informed the Governor that Te Teira could not sell without the consent of Weteriki and himself. Teira replied that Weteriki was dying (he is since dead), and that Paora was bound by the act of his relative, Hemi, who concurred in the sale. William King then rose, but before addressing the Governor said to his people:—"I wish only to say a few words, and then we will depart." Then, turning to the Governor, he said: "Listen, Governor! Notwithstanding Teira's offer, I will not permit the sale of Waitara to the Pakeha. Waitara is in my hands. I will not give it up; *e kore, e kore, e kore* (*i.e.* I will not, I will not, I will not). I have spoken;" and thereupon abruptly withdrew with his people.

William King was one of the Nagatiawa who had retired to Cook's Straits, whence he returned to Taranaki in 1848. Though a well-born chief, his land-claims are not considerable, and lie chiefly, if not wholly, to the north of Waitara. On his return to Taranaki, being still in fear of the Waikatos, he applied to Tamati Raru, Teira's father, for permission to build a pa on the south bank, which was granted. He put up his pa accordingly close to one occupied by Teira's party; but his cultivations are on the north side of the river. Rawiri Raupongo, Tamati Raru, Retimana, and the other members of Teira's party, have cultivated the block sold to the Governor; but King has been joined by a number of natives who have gathered about him since his settlement at Waitara, and these men have encroached with their cultivations upon the proper owners. This has been a source of dissension, and one reason determining the sellers to part with their land. King's particular followers, who have been enjoying the use of the land without any claim to share in the proceeds of its sale, naturally support him in his opposition.

W. Kingi's arguments against the sale of the land are stated by the District Land Commissioner in the following terms:—

W. Kingi avowed his determination to oppose the sale, without advancing any reason for so doing. Upon which I put a series of questions to him, which I called upon the Rev. Mr. Whiteley to witness, viz.—

Q. Does the land belong to Teira and party?

A. Yes; the land is theirs, but I will not let them sell it.

Q. Why will you oppose their selling what is their own?

A. Because I do not wish that the land should be disturbed, and, though they have floated it, I will not let it go to sea.

Q. Show me the correctness or justice of your opposition.

A. It is enough; Parris, their bellies are full with the sight of the money you have promised them, but don't give it to them. If you do, I won't let you have the land, but will take it and cultivate it myself.

This petty dispute was the proximate cause of the war. The Governor gave orders that the land purchased from Teira should be surveyed for

sale, and gave instructions to the officer commanding the troops at New Plymouth to protect the surveyors, and to proclaim martial law if he should consider it desirable to do so.

W. Kingi and his followers having forcibly interfered with the survey, Lieut.-Col. Murray made use of the discretionary power entrusted to him, and placed the district under martial law on the 22nd February, 1860. Colonel Gold arrived soon after with reinforcements, and assumed the command. The whole military force at Taranaki, however, at that period amounted to no more than 340 men. With this force Colonel Gold attacked a small pa, which W. Kingi had built within the limits of the disputed land. The pa was abandoned during the night, and destroyed on the following morning.

On the 24th March information was received that the Taranaki tribe, who inhabit the country at the base of Mount Egmont and south of New Plymouth, were about to make an attack upon the town. On the 27th they arrived at Omata, within about 4 miles of New Plymouth, where they erected two pas. On the following day a body of troops marched out by one road and militia and volunteers by another, for the purpose of bringing in some settlers who had remained at Omata, and who were supposed to be in danger. Both bodies were soon engaged, and the militia and volunteers particularly distinguished themselves, and inflicted considerable loss on the enemy. Just before dark Captain Cracroft, of H.M.S. Niger, with a part of his ship's company, made a gallant attack upon one of the pas, of which he obtained possession, almost without resistance, the enemy being taken completely by surprise. On the 29th the Taranakis retired to Warea, about 25 miles south.

In the latter end of April Colonel Gold, having received reinforcements from Auckland, marched to Warea with about 450 men, including artillery and naval brigade. The numerous deep and swampy ravines which intersect the whole face of the country, generally at right angles to the coast line, render the sea-beach itself the only practicable line of march for troops, except in the immediate neighbourhood of New Plymouth, where some of them are rendered passable by means of bridges. This peculiarity, as well as the dense masses of high fern and flax which cover the country outside of the forest, is very favourable to the Maories, who are excellent skirmishers, and know well how to take advantage of the natural features of their country. On this occasion, being either taken by surprise, or not having quite made up their minds what course they should adopt, they offered no resistance, and the troops returned to New Plymouth after destroying several pas.

In the same month a reinforcement of 500 men arrived from Australia, and an entrenched camp was established near the mouth of the river Waitara, and garrisoned by a small detachment.

In June W. Kingi built and occupied a strong pa in a commanding position, about 2,000 yards from the camp, very near the boundary of the disputed land. The communication between this pa and the forest in rear was secured by a chain of smaller pas, all of which were occupied by the enemy.

Some of W. Kingi's followers having assumed the offensive, by firing upon a reconnoitring party, it was decided that an attack should be made

upon the pa. Accordingly, on the 27th June, a force of about 350 men, under the command of Major Nelson, 40th Regiment, marched out of the camp with the intention of surrounding and capturing the pa. With this object Major Nelson divided his force into three detachments, one of which, accompanied by two 24-pounder howitzers, was to attack the pa in front, while the other two were to turn both flanks, and cut off the retreat of the enemy. Unfortunately the force employed was very much too small for the purpose. The howitzers failed to effect a breach in the pa, and the detachments, being too far apart to afford each other support, were unable to reply effectively to the close and destructive fire which was maintained by the enemy's skirmishers in the high fern. The troops were at length compelled to retreat, with the heavy loss of 30 killed and 34 wounded.

At that date the military force at Taranaki amounted to—

Troops and naval brigade	1,188
Militia and volunteers	573
Total	1,761

comprising about 1,500 effectives.

Colonel Gold soon afterwards left the colony, on his promotion to the rank of Major-General. In a speech addressed to the officers of his regiment on parting he used the following words:—

> I need scarcely now inform you that the reasons for my not being allowed to attack William King for a considerable period were political ones; nor need I say that I do not regret having foregone my own aggrandisement and *éclat* as a military officer in the eyes of the world, rather than risk some 2,000 women and children being barbarously murdered by a sudden nocturnal onslaught of the ferocious and bloodthirsty savages, concealed in the closely approximating bush.

I think it is only due to an officer, whose conduct was the object of persistent and unceasing depreciation on the part of the newspaper press of New Zealand and Australia, to say, that, whilst it is more than doubtful whether any effort on his part, with the very limited force at his command, could have done anything material towards reducing the Maories to submission, it is certain that for the thoughtful and provident care with which he watched over the safety of the lives and property of the settlers, he merited from them a measure of gratitude which he was far from receiving.

When the intelligence of the unfortunate attack on Puketakauere reached Melbourne, Major-General Pratt, C.B. commanding H. M. forces in Australia, determined at once to proceed to the seat of war, taking with him every available soldier. The colony of Victoria was, with the consent of its government, entirely denuded of troops, and the other Australian colonies very nearly so. These troops were despatched as rapidly as possible during the month of July to Taranaki, where the General and staff arrived on the 3rd August. The force at the seat of war at that time occupied, besides the town of New Plymouth, four detached posts, two of which were to the north and two to the south of the town. Those on the north comprised an entrenched camp on the left bank of the Waitara, one mile from its mouth and about ten from New Plymouth, and a block-house, commonly known as the Bell-block Stockade, at the village

of Hua, about four miles from the town. There was also a block-house at the mouth of the Waitara, which was garrisoned from the camp.

The posts on the south were the Omata Stockade, about four miles from New Plymouth and a little inland, and an entrenched camp on Waireka Hill, about a mile beyond Omata, and separated from that post by a deep and densely timbered ravine, which rendered a considerable force and extraordinary precautions necessary in escorting provisions and ammunition to the camp.* Within the town itself were two small but strong forts, Marsland Hill and Fort Elliott, and it was partly surrounded by a chain of small block-houses, but was unprovided with a continued enceinte of any kind; and as the forest approaches within a very short distance of it, and many deep and precipitous gullies, the sides and bottoms of which are thickly clothed with fern and scrub, extend from the bush through the line of posts into the town itself, the continued presence there of a large body of troops was indispensably necessary to guard against a night surprise, in which the town would have been burnt and the women and children in all probability murdered.

The total armed force at the disposal of the Major-General at this period amounted to a little over 2,000 rank and file, including the naval brigade and all the men borne on the muster-roll of the volunteers and militia. From these last must be deducted a large proportion necessarily employed in civil capacities, as boatmen, sailors, carters, bakers, butchers, &c. leaving about 2,000 for the whole available force. Of this number little less than one-half were stationed in the various outposts, and so large a proportion of the remainder was, as above explained, compelled to remain in the town, that only about 500 rank and file could be depended upon as available for active military operations at any distance from the town, except immediately in front of the Waitara Camp, where they might have been temporarily reinforced by a part of its garrison. It was found quite impossible to obtain accurate information as to the strength of the Maories actually in arms in the vicinity, but they were generally estimated at from 1,700 to 1,800, of whom it was supposed that about one-half, consisting of the Ngatiawas under Wiremu Kingi, and the Waikatos, had their head quarters in the Waitara district, their most advanced post being Puketakauere; while the remainder, comprising the Taranaki and Ngatiruanui tribes were engaged in an attempt to invest the Waireka camp on the south, by means of long lines of rifle-pits supported by pas. The base of operations of both these parties was the dense and almost impenetrable forest, which, spreading from the slopes of Mount Egmont, covers a great part of the province of Taranaki, and stretches all along the coast line to within a short distance of the sea-shore. For many miles north and south of New Plymouth, this great forest is only separated from the sea by a narrow belt, varying from one-and-a-half to four miles in width, of land either naturally free from timber or artificially cleared. A comparatively small portion even of this contracted space is under cultivation, the rest being generally covered with very thick fern, often from 5 to 10 feet in height, interspersed with brambles. The whole face of the country is intersected by a network of wide, deep, and often precipitous ravines, generally swampy at the bottom, and their

* See Map, Plate I.

sides covered with dense timber and tangled scrub. These ravines, most of which are not visible until their edge is reached, connected as they usually are with the forest, offer peculiar facilities for marauding parties of the enemy to prowl about at night, and lie in wait for and murder solitary European stragglers.

Under cover of the forest the two main bodies of the enemy were enabled to keep up a constant communication, and to concentrate their whole force in a few hours on any point which they might wish to attack, without giving the least warning, whilst on the other hand no movement of the troops could take place without the enemy being immediately aware of it. The real sympathies of most if not all the so-called "friendly Maories" were undoubtedly with their own race, and, as it was impossible to obtain any information of the position or intentions of the enemy so long as he remained in the forest, except through them, it is not surprising that the rebels had more perfect intelligence than the military authorities. In this respect the general found himself in a far worse position than that of the officer commanding the troops in the former war, who possessed a powerful and faithful ally in the Ngapuhi chief "Waka Nene." It was evident that the friendly Maories at Taranaki were not much to be relied upon, and it was quite certain that they were in the habit of giving information to the enemy ; nevertheless, it was impossible to get rid of them. The only intelligence, imperfect and doubtful as it was, that could be obtained, came from them, and to have driven them away would have been tantamount to declaring war upon the whole native race.

Major-General Pratt on his arrival found a very difficult task before him. It was necessary at the outset to proceed with great caution. The enemy were well aware that all the reinforcements which had hitherto arrived were drawn from Australia, which was now drained of troops; and they had been led by designing persons whose interest it was to promote a war of races to believe that England was at war with France, and could send no troops from home. The traditions of Heke's war, in which the troops suffered several reverses at the hands of the Maories, and never succeeded in gaining any decisive advantage over them, led them not unnaturally to believe themselves well able to cope with and overcome an equal number of soldiers. They found an easy mode of inducing the Governor not only to withhold reinforcements from the real seat of war, but even to withdraw troops from thence, and thus to paralyse the general's operations at a critical juncture, by merely holding out vague threats of a descent upon Auckland. In the same manner, by actually and constantly menacing New Plymouth, which was full of women and children, they compelled the general to keep a large force always within the town. Thus they were enabled with the greatest ease at any time to bring into the field a much larger number of men than General Pratt was able to oppose to them. This, however, would have been of little consequence had it induced them to leave the shelter of their strongholds and to fight in the open country. This was far from being the case. They had no intention of fighting except in strong positions, judiciously chosen, and fortified with great art and ingenuity by themselves. The mere loss of one of these positions would not have been of much importance to them; but had the general, with all the little force at his command, been repulsed in an

attack upon them, consequences of the most serious kind would have ensued. Indeed it appeared more than probable that any such failure would lead to a general rising of all the wavering tribes, not against Her Majesty's supremacy alone, but against the very existence of the European community. In such an event the war would have assumed a character and proportions little understood or contemplated by those who, in complete ignorance either of the nature of military operations or of the features of the country and the character of its population, spoke of the total subjection of the Maori race as no very difficult matter.

Little is known of the interior of the northern island of New Zealand, but it is certain that its inhabitants are not the least warlike among the Maori tribes; and it is probable that the complete conquest and subjugation of the country would be a task not very inferior in magnitude or difficulty to that which the Romans had before them when they undertook the conquest of Britain.

General Pratt was of opinion that the best mode of avoiding such a disastrous complication, and of bringing the war to an end before the great mass of the tribes should be committed to it, would be to afford them a practical proof, that, although the hasty attack on Puketakauere—undertaken before his arrival—had failed, it was in his power to take their strongest pas by a systematic and irresistible mode of attack, without much difficulty or loss on his part. In order to do this it was necessary to increase the strength of his moveable column. With this view he was desirous of abandoning the Waireka camp, the occupation of which was then useless, as the Omata stockade, which could be held by 50 men, was a sufficient outpost in that direction. This step would have given him an immediate addition of about 250 men; but there were serious objections to its being at once carried into effect. The camp was actually besieged by the whole force of the southern tribes, and to have withdrawn the garrison in the face of the enemy without a battle would have been looked upon by them as a confession of defeat; whilst to have attacked their formidable line of defences with the necessary certainty of complete success would have required a larger force than he could at that time employ, without leaving the town almost defenceless, and at the mercy of the Waikatos and Ngatiawas.

The general therefore determined upon the following plan of action: first, to hasten by every means in his power the departure, which had already commenced, of the women and children to the southern island, when a considerable portion of the permanent garrison of New Plymouth would be added to his available field force; and in the meantime to employ the troops in surrounding the town with a palisade and ditch, and in making gabions for siege operations, should they be required. Next, to attack and drive the southern natives from their position at Waireka. Then, reinforced by the garrison of that post, to march to the Waitara and to attack and capture Puketakauere, and the chain of pas which connected it with the forest. Then, in the event of the enemy taking refuge in the bush and refusing to submit, he proposed to follow them up to their strongholds by the system of operations which he afterwards carried out with complete success. Lastly, he intended to follow the Taranakis and Ngatiruanuis into their own country, and to inflict a severe and well-merited chastisement upon those tribes.

The failure of a portion of this plan, and the necessary postponement for some time of the remainder, arose entirely from circumstances over which the general had no control. He proceeded to Auckland for the purpose of requesting the support and assistance of the Governor and Executive in effecting the removal of the women and children. This was promised, and steamers were despatched to New Plymouth to convey them to Nelson, in the middle island.

During the general's absence, which only lasted for a few days, the enemy adopted a most unexpected and unaccountable step, in suddenly and simultaneously abandoning their strong positions both at Puketakauere and Waireka. The Waikatos proceeded northwards to their homes, the Taranakis retired to Tataraimaka and Kaihihi, the Ngatiruanuis returned to their own country, W. Kingi and his followers fell back into the forest, and all the great works which had cost the Maories months of hard labour, fell into the hands of the troops. As the officers of the native department at Taranaki were of opinion that the Waikatos at least, if not the southern natives, would return in all probability in much larger numbers in about a month or six weeks, the general, on his return from Auckland, resolved to employ the interval in completing the preparations upon which he had previously decided, not, however, neglecting any opportunity which might offer of inflicting a blow upon the rebels who remained in the province.

An unexpected difficulty now arose in removing the women and children The alarm which they had previously experienced, and which had induced them readily to consent to leave the province, disappeared with the main body of the enemy, and nearly all of them absolutely refused to embark. The general at length finding that it was out of his power to effect their removal without the use of actual violence, was most reluctantly compelled to abandon the attempt, and to allow about a thousand women and children to remain, thus depriving himself of the services of about half a battalion of soldiers. In the mean time, no chance of harassing the enemy was lost. All the pas, upwards of twenty in number, many of them very strong and of quite recent construction, which they had occupied outside of the forest, were destroyed, and in them large stores of provisions. Many attempts were made to surround the enemy in their pas and to prevent their escape, but these were always defeated by the accuracy of their information, their vigilance, and the rapidity with which they were able to move. It was said indeed at the time, and perhaps generally believed, that much more might have been done by a judicious use of the services of the militia and volunteers, whose knowledge of the country and of the natives would, it was thought, enable them to follow the enemy through the bush with advantage. This, however, was a mistake. Soon after the general's arrival he was waited upon by the major commanding, and all the captains of the militia and volunteers, who offered, if their men were relieved from garrison duty and from work in the trenches, to take them out in small parties every night, and lie in wait for the rebels. They undertook, in this manner, to clear the open country of their marauding parties, and to drive them into their pas in the bush. The general at once accepted this proposition, but on the following day, when the officers explained the arrangement to their companies, the men refused to carry it out. They said that they would of course go wherever they might be

ordered, but they would not volunteer for such peculiarly hazardous service, and they did not think that they ought to be called upon to perform any service on which the troops were not also employed.

Without entering into a detailed account of all the operations which were carried on under these difficulties, with more or less success, but without any disaster, during the months of August and September, it may be mentioned here, that all the accounts of disastrous failures, disgraceful retreats, and misconduct on the part of officers high in command, which, having first appeared in some of the New Zealand newspapers, were copied and adopted by the *Melbourne Argus*, and subsequently by the *Times*, were wholly without foundation, and destitute of truth. It is true, that, for the reasons before stated, nothing very brilliant or decisive could be effected during that period, but much mischief was done to the enemy, and nothing like disaster or defeat occurred.

On the 18th September the Governor addressed a letter to General Pratt, in which he recommended a system of "sudden, secret, and constant attack when and where they least expect it," and urged that advantage should be taken of our superiority of force at the time, as the proportions might be reversed in a few weeks.

Perhaps the best illustration that can be given of the difficulties of the general's position, will be to quote an extract from his reply to that letter. He says:

During the past few weeks the troops under my command have destroyed between twenty and thirty pas, many of them very recently built, and provided with rifle-pits and other defences constructed in the most careful and elaborate manner.

The rebels did not venture to defend any of these places, but deserted them all on the approach of the troops, in some cases in such haste, that, on our entry, we found meat half-cooked on their fires. We have also destroyed a great number of "wharres," or native habitations, and a considerable quantity of provisions.

During the whole of this period the enemy have been suffering very severely from sickness, caused by privation and exposure; and I have certain information that they have lost a good many men, including several of their most influential chiefs, who have been killed in action, or have died of their wounds. The whole of our casualties, on the other hand, throughout all these operations amount to only one man killed, and four wounded. I cannot conceive that such a result can be looked upon as a success on the part of the enemy.

The plan which your Excellency proposes of harrassing them by secret, sudden, and constant attacks, by bodies of troops without baggage, is, in my opinion, impracticable. It is impossible to surprise them, as the scouts, who are constantly on the watch about their pas, will always give them sufficient notice to enable them to effect their escape should they be desirous of doing so, or to prepare for defence if they mean to remain. Experience has proved that to send troops unprovided with artillery to attack a pa entails certain failure, accompanied with an useless loss of men and of prestige. I consider it of the highest importance, not only to the successful termination of the present war, but to the future peace of the colony, that the Maories should become convinced of the superiority of the troops in warfare, and of the hopelessness of their endeavouring to gain any material advantage over us; and I cannot think that it would be wise or justifiable knowingly to place the troops in a position in which that superiority would disappear, or perhaps be converted into inferiority.

I arrive at a different conclusion from the opinion expressed by your Excellency, that the present excess of our numbers over those of the enemy in this province places us in a more favourable position for the prosecution of the war than we shall probably be in two or three months hence, when the proportion may be reversed. On the contrary, the principal difficulties with which I have now to contend arise from this very cause; and I am satisfied that any increase in their numbers, which might give them sufficient confidence either to defend a pa in an accessible position, or to accept battle in the open

country, would lead to a much more satisfactory result than a lengthened continuance of the present state of affairs.

The justice of these opinions was signally verified by the event.

In the beginning of October the general received intelligence that the Taranaki tribe had built a couple of new pas on the river Kaihihi, about sixteen miles from New Plymouth. He determined to attack them. There were evident signs reported by a reconnoitring party that the natives intended to defend them, inasmuch as they had covered them with fascines of green flax. He looked upon this as a favourable opportunity for making a serious attack upon them. He left New Plymouth on the 9th of October with 800 men, and the following artillery, viz., one 8-inch gun, two 24-pounder howitzers, two cohorn mortars, and some rockets. To give an idea of the difficulty of moving in that country, I may mention, that the 8-inch gun, which was slung on a devil carriage, required eighteen bullocks to draw it. It was attended by six carts carrying the platform, carriage, ammunition, &c., requiring in all nearly sixty bullocks for one gun. The train of carriages for the whole column, comprising only 800 rank and file, was considerably more than a mile in length, although nothing unnecessary was carried. That night the force encamped at Tataraimaka, and on the following morning reached their destination.

The enemy's defences consisted of three pas, two on the north, and the third on the south side of the river Kaihihi. Their flanks were well covered by deep and impassable ravines, and the only way by which the pas could be approached was flanked by a line of rifle-pits on the margin of a patch of dense forest. The pas were sufficiently near for mutual support, and were well provided with flank defence.*

The nature of the ground made it necessary first to attack Orongomaihangai, the strongest of the three.

On the morning of the 11th, a working party and guard of the trenches advanced to within 250 yards of the pa, and commenced the construction of a parallel. The enemy showed themselves during this operation, but did not for some time open fire. They appear to have misunderstood the nature and object of the work, and to have been in momentary expectation of an assault.

It was not until the breastwork was nearly completed, and the guns brought up, that they became aware of their mistake. They then opened a sharp fire from the pa and from the rifle-pits. The guns and mortars commenced shelling the pa before noon, and kept up their fire till dark, without making a breach in the stockade.

In the course of the night approaches by sap were commenced and carried on till morning, when it was discovered that the enemy had abandoned all their pas during the night.

It appears that, although the shells passed through the stockade without doing it any material damage, they searched the rifle-pits, and must have inflicted considerable loss on the enemy.

General Pratt's intention was to follow up this success by a march further to the south, with the view of attacking other pas belonging to the same tribe, but he was reluctantly compelled to abandon this intention, by the receipt of a letter from the Governor, informing him that a strong force of Waikatos was already on the march for the Waitara.

* See Plates II. and III.

Considering the nature of the country, the total absence of roads, and the impossibility of securing a communication with the town by sea, owing to the exposed and rocky formation of the coast, it could not be anticipated that any operations of importance further south could be concluded in a less time than several weeks, and in the face of the Governor's warning it would have been extremely imprudent to have attempted any thing of the kind at that time. A few days afterwards it was ascertained that the Waikatos had actually arrived at W. Kingi's pa, whence they sent a challenge to Mr. Parris, the land purchase commissioner, of which the following is a translation:

To Mr. Parris, Puke Kohe, 1 Novr. 1860.

Friend, I have heard your word—come to fight me, that is very good; come inland, and let us meet each other. Fish fight at sea; come inland, and stand on our feet; make haste, make haste, don't prolong it. That is all I have to say to you—make haste.

From Wetini Taiporutu.
From Porokore.
From all the Chiefs of Ngatihaua and Waikato.

On the evening of the 5th of November intelligence was received that the Waikatos had taken possession of Mahoetahi, an old pa in a strong position on the road from New Plymouth to the Waitara. Major-General Pratt immediately wrote to Colonel Mould, R.E., who was then in command at the Waitara camp, to inform him that he intended to attack the enemy early on the following morning, and to desire that he would make a simultaneous attack on the other side, with a portion of his force.

In pursuance of this plan, the general marched from New Plymouth with 700 men at daybreak on the 6th, and immediately on his arrival at Mahoetahi commenced the attack, without waiting for the detachment from the Waitara, which had been accidentally delayed, but which arrived in time to take part in the engagement before its close.

The Maories made a gallant but ineffectual defence, and were pursued for several miles, until they took refuge in the forest. The loss of the troops and militia on this occasion amounted to 4 killed and 15 wounded; of the natives 31 were found dead on the field and 5 wounded, and traces of blood were seen all along their line of retreat, proving that many of those who succeeded in reaching the bush must have been wounded.

The officers of the native department, who had means of obtaining intelligence on the subject, estimated their loss at about 100.

The Governor, on learning the result of this action, was of opinion that the Waikatos would very probably leave Taranaki and turn their whole force upon Auckland. Under this impression he called upon General Pratt to detach no less than 400 rank and file from his already small force to assist in the defence of the capital. The contemplated movement of the Waikatos did not take place, and the only result of the transfer of these troops to Auckland was entirely to cripple the general's operations, and effectually to prevent him from taking any immediate advantage of his success. About the end of the month, a portion of the 14th Regiment having arrived in Auckland, the troops that had been detached from Taranaki were sent back again, and the general determined to carry out the system of attack upon the enemy's positions in the bush which he had contemplated from the first; but, during the month

of December the weather was so bad that nothing could be done, the country being flooded with rain.

On the 27th of December the general marched from New Plymouth to the Waitara with the whole of his available force.

The enemy had in the meantime established a new pa, Matarikoriko, in a very formidable position, about two miles and a-half from the camp, and nearly surrounded by deep, precipitous, swampy ravines, fringed with concealed rifle pits, the whole of the neighbouring country being covered with fern, from six to eight and even ten feet in height, and so dense that a horse could with difficulty force his way through it.

The general determined to establish an advanced post at Kairau, about 900 yards from Matarikoriko. From this point he proposed to attack the pa by regular approaches. On the 29th he marched to Kairau with 900 men, and immediately commenced the erection of a redoubt, the working party being protected on all sides by skirmishers.*

The work proceeded without molestation until about 9 A.M. when a heavy fire was opened on the troops from the concealed rifle-pits, as well as from native skirmishers in the high fern. The work was completed about 6 P.M. and garrisoned, but the firing continued on both sides throughout the night. In the morning the enemy showed a white flag, and the day was spent in strengthening and improving the work. On the morning of the 31st it was found that the Maories had abandoned all their works in the neighbourhood, and had fallen back on the forest at Huirangi. General Pratt described their deserted position as "one of the most formidable he ever saw," and as "chosen with singular sagacity." The pa was demolished, and its site occupied by a block-house to contain 60 men.

The enemy now occupied a line of rifle-pits upwards of a mile in length, skirting the edge of the forest. These being entirely concealed from view it would have been a mere waste of ammunition to attack them by artillery fire, and they were so ingeniously arranged for mutual support that an attack by *vive force* could only have led to a useless waste of the lives of the troops. It was therefore determined to push forward the advance by a chain of redoubts to within about half a mile of the forest, and from thence to approach and pierce the centre of their position by double sap.†

The sap was commenced on the 22nd January, and on the same night, or, more correctly, on the following morning before daybreak, the enemy attacked the most advanced or No. 3 redoubt in force, and with a degree of vigour, determination, and military skill, which few persons had previously given them credit for being able to command. The attack commenced some time before dawn, and was gallantly maintained until after the break of day, when it was seen that they had advanced in regular military order, with storming party, supports, and reserve. Although the

* In a dispatch dated 31st December, General Pratt says,—"My force, after being joined by parties from the Waitara camp and other positions, amounted to 900 rank and file of all arms, which was all I could muster, after leaving the town and other posts in security, and requiring some assistance from H.M. ships 'Cordelia' and Victoria;' and I note this, in consequence of the great misstatements which are circulated regarding the amount of force at my disposal for aggressive operations."

† The positions of the redoubts and the line of sap are shown in the accompanying map, Pl. I.

redoubt was well constructed, and garrisoned by a considerable portion of the 40th regiment, it was not till reinforcements had arrived from the rear that the attack was finally repulsed, and the enemy driven back into the forest.

The sap was then pushed steadily forward, small redoubts being erected at intervals along the line to prctect its head, until the 27th, when the enemy, finding their line of defence almost cut in two, abandoned the whole position, and fell back about a mile and a half into the bush, where they had established a similar but still more formidable series of works of defence. A few days were then occupied by the troops in constructing a strong work (No. 6 redoubt) at Huirangi, at the edge of the forest, and in clearing a road to the front, through a part of the bush. They then pushed forward about three quarters of a mile, and constructed another redoubt (No. 7) under a heavy fire from the front and both flanks.

In front and on the right of the redoubt lay a great amphitheatre of lofty rugged hills and deep ravines, thrown together in wild and picturesque confusion.

On the left was a rocky precipice overhanging the river Waitara, of which it here formed the left bank. The brow of each hill, at a distance of from six to eight hundred yards from the redoubt, was crowned by irregular lines of rifle-pits, so arranged as to flank each other and to command every ravine which an assailant would be compelled to cross, and so well concealed by the stunted bush which grew plentifully on the hills, that their position could only be guessed at by the smoke from the musketry of their occupants.* The right of the enemy's line of defence rested on the river at Pukerangiora, a commanding eminence, long famous in the annals of Maori warfare, and now crowned by the Pa Te Arei.

Immediately in rear of the enemy's position lay the great forest, stretching far away over mountain and valley into the distant and unknown interior.

From No. 7 redoubt the approach was carried on by single sap as far as No. 8, or about a quarter of a mile; from this point the double sap was recommenced, demi-parallels being thrown out to cut through the lines of rifle-pits on the left front of the attack. The whole of these works were carried out under great difficulties, owing to the incessant fire kept up by the enemy in front and on both flanks, and their repeated night attacks upon the head of the sap; notwithstanding which the troops suffered but little loss owing to the able and careful manner in which the works were designed and carried out by Colonel Mould, Commanding Royal Engineer.

On the 12th of March, a truce was granted to the Maories at the request of W. Thompson, a very influential Waikato chief, who had been deputed by the tribe to visit Taranaki and report upon the progress of the war there. Finding that his people had suffered and were suffering heavy losses in killed and wounded, and that they were compelled day by day to fall back before the steady and irresistible advance of the sap, he became anxious that hostilities should cease. The truce, however, only lasted for three days, the Maories having refused to agree to the terms offered them by the Governor.

On the morning of the 15th, three 12-pounder Armstrong guns, and

* For the mode of construction of these pits, see Pl. IV.

two 8 and two 10-inch mortars which had just arrived from England, were moved to the front and placed in position. At 11 a.m. the enemy's white flag was lowered, and a red one hoisted, upon which firing recommenced on both sides.

On the night of the 16th, a last attempt was made to destroy the head of the sap, which was defeated by the explosion of an 8-inch shell which had been attached to the sap-roller for that purpose.

On the 18th the enemy finally sued for peace, and the war came to an end.

The Waikatos, having agreed to give up the whole of the arms and plunder they had taken, returned to their own country accompanied by Wiremu Kingi, whose immediate followers came in, and made submission.

Mr. Ridgway: It was stated by Mr. Buxton in the House of Commons the other night that the war was raging fiercely in New Zealand now. I should like to ask Captain Pasley whether it is in his knowledge that such is the fact?

Captain Pasley: I do not believe there is any war in New Zealand at present. The Australian mail has just arrived, and there is nothing about it in that; on the contrary, everything appears quite quiet.

Mr. Ridgway: I am pretty well up in New Zealand affairs, and I beg to state that the assertions which have been made with reference to the prevalence of war in New Zealand are totally without foundation. General Pratt has accomplished the defeat of the natives. There has been no war in New Zealand since the arrival of General Cameron. If the time would permit, I would have asked some more questions.

Mr. Fitzgerald Foster: What is the greatest number of natives that ever met our troops during the recent war?

Captain Pasley: It is impossible to state exactly. It is supposed that the number of natives engaged in the operations just detailed was about 2,000. It is impossible to say whether the whole of the 2,000 were actually engaged in action on any one occasion.

Mr. Foster: Did you ever hear it computed what number of men the natives could bring into the field at once—I do no not mean in the late war, but in future?

Captain Pasley: It would depend entirely on the union of the tribes, which is a very unlikely thing to take place. In the first place, the Ngapuhi tribe and its chiefs appear to be as firm friends of ours as ever they were, and they constitute one of the most numerous and powerful of the Maori tribes. Taking the population of the northern island south of Auckland, that is, exclusive of the Ngapuhis, it might be about 40,000 altogether, and probably one-third would be adult males.

Mr. Ridgway: I can state that the population of adult males in New Zealand is 30,000; including men, women, and children, 56,000. The Europeans were 70,000, and since then the augmentation of the British forces has considerably increased that number.

LECTURE.

Friday, April 11th, 1862.

MAJOR-GENERAL the Hon. JAMES LINDSAY, M.P., in the Chair.

THE WAR IN NEW ZEALAND.

By CAPTAIN C. PASLEY, R.E.

PART II.

IN a paper which I had the honour to read before this Institution a few weeks since, I gave a short account of the history of New Zealand down to the conclusion of the recent war. I propose on the present occasion to offer a few observations on the character of warfare in that country, on the kind of arms that the natives use, with their reasons for adopting them, and on the peculiarities of their defensive works, which, although inapplicable to European warfare, are well deserving of consideration as evincing a natural aptitude for war on the part of the Maories which would be remarkable in any nation, and the existence of which amongst a people so recently rescued from total barbarism is probably unparalleled.

A great deal has been said of the apparent absurdity of a considerable number of troops being kept as it were at bay by a not very numerous body of semi-savages. In a leading article dated the 20th December, 1860, "The Times" contrasts the two pictures of British prowess presented on the one hand by the small allied force (chiefly British) dictating terms of peace to the Chinese Emperor "on the very walls of a capital containing 2,000,000 of inhabitants," and on the other, by "a force of 3,000 effective men commanded by a veteran general, and with an unusually large number of colonels and other officers amply equipped with artillery and with all the munitions of war, drawing its supplies by sea, and backed by a British fleet of six ships of war, which can hardly hold its own against a horde of naked savages never exceeding 600, and now probably reduced to some 120; armed with wretched flint and steel muskets and tomahawks, unprovided with the scantiest apparatus of warfare, and almost destitute of subsistence." The writer goes on to say that a force of 1,000 men under General Pratt "had already declined the siege of a pa of somewhat more than average strength."

As an evidence of the recklessness of assertion which characterised the article in question, I will simply observe, that the number of effective troops (including Naval Brigade) at the disposal of General Pratt at the period referred to was just one-half of the number stated; that, so far from there being "an unusually large number of colonels and other officers," the force laboured under the disadvantage of possessing unusually few officers of all ranks; and finally that the force under General Pratt,

which was 800 (not 1,000) strong, so far from declining the attack of a pa, had both attacked and captured it, and an account of the capture had actually been published in "The Times" itself two days before the leading article appeared.

I need not continue the quotation. If any of my hearers wish to learn how the honour of our troops, and consequently of our nation, may be vilified in the eyes of the world on the authority of obscure and unscrupulous colonial newspapers, I would refer them to that article, and to some others which appeared in "The Times" about the same period. Did time admit of it, it would not be difficult to show the utter fallacy of the comparison between China and New Zealand, and it would be equally easy to show on the present occasion that the statements of comparative force, arms, &c.—in short, the whole of the supposed facts mentioned in the extract which I have just quoted, as well as nearly all those which follow, are founded entirely on false information.* I readily acquit "The Times" of any wilful falsification of facts; I only say, that, before giving the weight of its great name and influence to statements affecting the credit of the British arms, it ought to take at least as much trouble to ascertain the truth as it generally does before commenting on matters affecting the character of an individual.

In this particular case "The Times" had, in the monthly letters of its Melbourne correspondent, which were regularly published without being noticed, and apparently without being read, by the writers of the leading articles, the means of correcting many of the falsehoods to which, no doubt unconsciously, it gave a world-wide currency.

I have alluded to "The Times," not only on account of its great circulation and influence, but because it happens to have been the only daily London paper that I had an opportunity of seeing during the period in question. What sort of remarks may have been made by others I do not know.

I ought, perhaps, to apologise for offering these few remarks, which may seem to have no direct bearing upon the subject of which I have now to treat; my excuse must rest on the peculiarity of the case. New Zealand is sixteen thousand miles away, and nearly all the officers and men who were engaged in the war are still either there or in Australia, too far off to make themselves heard with effect. General Pratt, it is true, has received what I may be permitted to call a well-merited mark of honour from our Sovereign; but the public does not form its opinions from an announcement in the Gazette, but rather from what it reads in the daily papers, in which, as far as I am aware, no recantation or apology for the unfounded calumnies formerly published against the troops has ever appeared; nor has justice been done by the press in England, either to the gallantry and perseverance with which the troops carried on operations of the most harassing kind, under extraordinary difficulties, or to the conduct of the general, who, disregarding the ignorant clamour of newspaper writers, went steadily on his way, without turning to the right or left, until he had carried the war to a successful conclusion, in such a manner as to gain for himself, and for the troops under his command, the respect of the enemy.

* For strength of troops &c. at various periods during the war, see Appendix A

Before entering upon a description of the arms and mode of warfare of the New Zealanders, I must observe, that one of the most fallacious opinions ever entertained by reasonable men, is, that because savages have often been able to offer a serious resistance to regular troops, under favourable circumstances, therefore any other force, no matter what, colonists, sailors, gold-diggers from Australia or California, men of any kind in short, provided they have not been trained as soldiers, would be much more efficient, owing to some imaginary power that every man *not* brought up as a soldier seems to be supposed to possess of getting through dense scrub and "supple jack," and of doing without supplies of provisions, clothing, and ammunition. In short, discipline is imagined to be a mistake, and organised movements worse than useless. Nothing can be more unfounded than such a notion. The Maories are infinitely more formidable enemies than the North American Indians, or any other savages with whom the English nation has had to deal, with the single exception of the Kaffirs, because they possess discipline and military organisation in a very high degree. On the other hand, the Naval Brigade, formed of detachments from the crews of Her Majesty's ships on the station (with a contingent from the steam-sloop Victoria, which was lent to General Pratt by the government of the colony of Victoria), constituted a very valuable reinforcement to the troops, not because they were less under discipline than the soldiers, but because they combined that discipline with that readiness at handling tools, and turning their hands to any kind of unusual work, for which seamen generally are justly celebrated.

I mentioned the Kaffirs just now, as an exception to the rule that the Maories are the most formidable race of savages that we have met. They were undoubtedly, before the recent breaking up and dispersion of their tribes, much more numerous than the Maories, and quite as warlike in their habits. I have heard that a distinguished officer, who served in the last war at the Cape, considered the Kaffirs to be "perfect light troops," and I can easily believe that they were so, without supposing them to have been superior to the Maories in skirmishing, whilst they were certainly inferior to them in the art of constructing works of defence; indeed I believe the Kaffirs never attempted anything of the kind. Our troops had also much greater facilities for carrying on war in South Africa than in New Zealand. They had there a definite frontier, either to defend or to advance from, as they thought proper; and all the great centres of population in the colony were far removed from any danger. They were able also to penetrate the country in all directions without much difficulty, and even to employ cavalry. The absence of all attempt at fortification also on the part of the enemy made our artillery only useful as an auxiliary, instead of being indispensable as a primary part of our field force.

All these conditions are reversed in New Zealand. Cavalry cannot be employed. Artillery, indispensable as it is, is transported with the greatest difficulty, even near the coast, and cannot be conveyed at all to any distance in the interior. Instead of having a well-marked frontier, all our settlements are dotted along the interminable coast line of a large island, the whole of the almost inaccessible interior of which is occupied by the Maories. These settlements have no communication with each other by

land, and but a very uncertain and precarious one by sea. We occupy detached spots on the circumference of the circle, whilst the natives have possession of the whole of the interior, and are able to throw themselves in force at any time upon whichever of our settlements may appear to be the most vulnerable.

I conceive, therefore, that in what I hope is the improbable event of a general war with the Maories, a large proportion of our settlements in the northern island will be untenable, and must be abandoned. It was this consideration, I believe, which induced General Pratt readily to acquiesce in the peculiar conditions under which the recent war was carried on. These were certainly very peculiar, and to my mind worthy of more than a passing remark, as evincing a sort of chivalrous feeling on the part of the Maories, which is, I think, deserving of our respect, and which ought not to be forgotten in carrying on negociations with them.

The Waikato nation, the most powerful, numerous, and warlike of the Maori tribes, and the promoters of the native King movement, decreed that there should be war at Taranaki, and nowhere else; that any of their young men who chose to do so might go and fight against the soldiers at New Plymouth, but that no settlers anywhere else were to be disturbed or molested in any way. Their decision was strictly carried out. There *was* war at Taranaki, and peace everywhere else in the colony. Although the friendly intercourse between the settlers and the Maories was occasionally a little interrupted by suspicions and even threats on both sides, it never ceased, except at the actual seat of war. Some two thousand Waikato warriors came down to the Waitara to drive the troops into the sea. They left about one-fifth of their number dead, and carried away (by permission of General Pratt) a ship-load of wounded, without having succeeded in killing or wounding amongst the soldiers anything approaching to the number they had lost themselves; and all this occurred in a position, or rather a series of positions, chosen and defended with admirable skill by themselves.

The war was a kind of tournament, or combat by champions; and if we except some outrages committed by the southern natives, and which were condemned not less strongly by W. Kingi and the Waikatos than by ourselves, it must be admitted that it was conducted on both sides with a humanity and consideration most unusual in civil wars, and which the Under Secretary of State for the Colonies (Mr. Chichester Fortescue) justly characterized in the House of Commons as being almost without parallel in the history of war.

The arms generally used by the Maories are double-barrelled guns (not "wretched flint and steel muskets," as stated by "The Times," but good percussion guns), and, for close quarters, tomahawks with long flexible handles, which enable them to reach an adversary's head over his guard. They are not ignorant of the value of the rifle, which is used by some of their marksmen, but as a general rule they prefer the double-barrelled sporting gun to any other arm.

In order to understand their reasons for this preference, it is only necessary to consider for one moment the peculiarities of their position. The interior of the island is very broken and mountainous, intersected by swamps, for the most part covered with dense forest, and entirely destitute

of roads or tracks practicable for wheeled carriages of any kind. It would, therefore, be impossible for them to employ artillery without losing all the advantages they possess in being able to move freely through the forest, and to advance from or retreat on their almost inaccessible fastnesses at pleasure. The absence of this important arm renders it necessary for them, when they meet the troops under circumstances in which our artillery is available against them, to keep as much as possible under cover. Even the use of long-range rifles, requiring a steady and prolonged aim, would expose them to some extent, not only to the fire of our own rifles, but to the destructive effect of shells.

They therefore trust to the closeness and rapidity of their fire, rather than to accuracy at a distance, and their plan usually is to invite and await an attack in rifle-pits, covered from distant fire and protected in front either by natural obstacles or by the double stockade of a pa.

Against an attack by *vive force*, probably no system of defence and no kind of arms could be more thoroughly effective than those adopted by the Maories. It is exceedingly difficult to make a serious breach in the stockades of a pa by artillery fire, even at a short range;* and any attempt to climb over or cut them down must be made at a distance of only a few feet from the muzzles of the guns of the defenders, who, being themselves well under cover, are able to overwhelm the storming party by a close and destructive fire, to which no effectual reply can be given.

Owing to the rapidity with which they can be loaded and fired, double-barrelled guns are much more effective at close quarters than rifles.

It has often been suggested that pas might easily be breached by means of powder bags, and several experiments have been tried at the Royal Engineer establishment at Chatham to prove the facility with which this can be done. The operation would no doubt be simple and effective enough if the pa to be breached were unprovided with flank defence, but such is never the case in fact. No military engineer in Europe understands better than the Maories the importance of flanking fire, and none could show greater judgment in securing that advantage, or in arranging works with reference to the formation of the ground, in such a manner as to afford each other mutual support.

Such being the case, the chance of a bag of powder being successfully placed and fired against the stockade would be extremely remote.

There remained then two modes of attacking these works, viz. shelling them, and approaching them by sap.

The former mode was adopted with so much success against the Kaihihi pas in October 1860, that the Maories resolved no longer to trust to pas, which they began to regard as mere "shell-traps," but for the future to construct their rifle-pits for the most part in spots difficult of access from the front, but with a retreat always open, and concealed in such a manner as to be pretty safe against distant fire, whether of artillery or rifles. They carried out this design with remarkable skill in their successive lines of defence at the Waitara, in the latter part of the war.

An assault upon these lines must have resulted either in a repulse or, at the best, in the capture of a few empty rifle-pits, with great loss to the troops and little or none to the enemy.

* I believe it has never yet been done.

Such a success as this would have done nothing towards bringing the war to a termination, but would, on the contrary, have been regarded by the Maories as a victory on their part.

It was then that the approach by sap was adopted, with what complete success we have already seen. Their want of artillery rendered it impossible for the Maories to offer any effectual resistance to this mode of attack. Any attempt to check it obliged them to expose themselves to the fire of troops under cover; and the result of this reversal of their usual tactics was, that, whilst the casualties amongst the troops were few, the enemy suffered severe daily losses in killed and wounded, and eventually gave up the contest in despair.

A short description of the position before which the troops under Major Nelson were repulsed in June, 1860, may perhaps be of some interest, as that was the last occasion on which a pa was successfully defended. It comprised two pas, Onukukaitara and Puketakauere, about 200 yards apart, crowning the two highest points of a hill about two miles from the mouth of the river, and 2,000 yards from the British camp.

Like nearly every commanding height in the neighbourhood, these two points had been formerly occupied by native pas, which however had been deserted, and allowed to fall into decay.

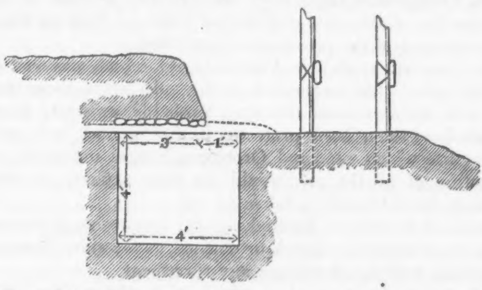
Soon after the commencement of the war, the enemy having been driven off the disputed land, took possession of Onukukaitara, which they restored, and greatly strengthened. They subsequently commenced working at Puketakauere, but two 8-inch guns having been in the mean time landed from H.M.S. "Iris," and placed in position in the camp, the garrison were enabled, by occasionally throwing shells into the pa, to prevent them from carrying out their design, and, beyond placing a single line of palisading on the parapet, they were unable to effect any material restoration of the old work, which consisted of a redoubt surrounded by a double ditch.

At the period of its abandonment by the enemy, Onukukaitara (commonly but incorrectly called Puketakauere) contained a quadrangular earthen redoubt about 22 yards by 18, with a command of 14 feet obtained by scarping the sides of the highest portion of the hill. This redoubt formed a sort of citadel to the pa. At the foot of the escarp, and surrounding the redoubt on three sides, was a trench for musketry (usually termed rifle-pits), about 4 feet in depth, and varying in width from 3 feet to 20, with traverses. Outside of the trench was a line of palisades partly double and partly single, but always sufficiently open to allow musketry fire from the trench to pass through it. At the northern angle was a palisaded outwork 26 yards by 10, containing a series of covered splinter-proof rifle-pits, connected by semicircular underground passages. A similar underground passage under the palisade of the main work connected the rifle-pits of the pa with the outwork.

At the south-east angle was an unfinished outwork, consisting of a breastwork and rifle-pits without palisading. From the south-western side of the redoubt an outwork, broken into flanks, and divided into several portions by interior palisading, extended for about 60 yards along the crest of the hill, surrounded by a double palisade with covered rifle-pits, some of which were incomplete. Beyond this again, towards the south, were a series of covered rifle-pits without palisading.

The design of the work was well adapted to the site, the strongest and best flanked defences being on the south-western side, where the hill rises from the plain by a gentle ascent. On the north-west and south-east sides the pa was protected by deep gullies, and on the north-east it was covered by Puketakauere pa, which was also in the occupation of the enemy, and which, notwithstanding its defective palisading, was capable of offering a serious resistance to an assault, and was so well covered by swampy and almost impassable gullies, that it would have been scarcely possible to attack it at all until Onukukaitara should have fallen. Both the pas contained several native huts, or "wharres," which were generally covered from distant fire.

On the 27th June, 1860, when the pa was attacked, 46 shells were fired from two 24-pounder howitzers at a range of about 400 yards without effecting a breach in the palisading. The rifle-pits were constructed in a very simple manner. A series of pits 4 feet wide, 4 feet deep, and 8 or 10 feet in length, were dug 3 feet back from the line of palisades. These were covered for about three-fourths of their width with split timber, over which was laid a covering of earth and fern 3 or 4 feet in thickness, leaving openings for musketry 1 foot or 15 inches wide along the whole length of



the pits. Posted in these pits, the enemy were perfectly protected from horizontal fire, and in a great measure even from vertical fire, unless heavy mortars were brought against them.* The difficulty experienced in effecting a practicable breach in a pa is chiefly due to the mode of fastening adopted for the palisading. The inner line is a regular stockade consisting of unhewn timbers, of dimensions varying according to the nature of the neighbouring forest, sunk several feet into the ground, and further strengthened by two or three horizontal ribands, to which every timber is firmly tied with a peculiar tough fibrous grass. Intervals of a few inches are left between the timbers, to serve as loopholes for musketry The outer line is not so solid as the inner. It consists of strong posts firmly planted in the ground at intervals of 8 or 10 feet, and connected by two ribands, which carry a row of palisades raised about 2 feet from the ground, in order to enable the fire from the rifle-pits to pass under

* Vertical fire from heavy mortars would soon render any pa untenable; but there were none available until a few days before the termination of hostilities. Before their arrival the Maories had, as before stated, adopted a new system of defence, against which vertical fire was comparatively ineffective.

them. The whole is so firmly bound together by the tough grass before alluded to, that shot and shell pass freely through both lines, often cutting completely through the timbers without causing any portion to fall.

When an attack is expected it is the custom of the Maories to cover the outer palisades with bundles of the long leaves of the New Zealand flax,* which offers some resistance to musketry, and serves in a great measure to conceal any damage that may be done to the palisades or stockade by artillery.

The above may serve as a general description of the mode of construction adopted in all pas, but the ground plan varies very considerably according to the features of the country.

The plan of the attack on the Kaihihi Pas (Plate II.) shows some of these varieties. It will be observed, that, whilst Orongomaihangai, occupying a bend of the river, was traced in a manner somewhat resembling a bastioned front, with the faces of the ravelin prolonged to meet those of the bastions, Pukekakariki was almost a perfect square unbroken into flanks (see Plate III.). Nevertheless, flank defence was far from being neglected. Owing to the extreme difficulty of moving artillery across the gullies on the right of the enemy's position, the attack was necessarily made upon Orongomaihangai first, the ground in front of which was swept by the fire of rifle-pits dug in the patch of bush on the right, and cut out of the crest of the precipitous river bank.

The same remark applies to Pukekakariki, which was well flanked by detached rifle-pits. Only a portion of the rifle-pits in these two pas were provided with splinter-proof covering, probably owing to want of time. Had the whole of them been protected in that manner, it is probable that the artillery fire which rendered Orongomaihangai untenable, and led to the evacuation of all the pas, would not have sufficed for that purpose, and that they must have been taken by sap.

The nature of the soil at Taranaki is very favourable to the construction of earthworks, whether for attack or defence, as the sides of an excavation, even if vertical, will stand without any revetment.

The redoubts, eight in number, which were thrown up by the troops during the attack on the Waikato position at the Waitara, had ditches eight feet in depth, vertical and unrevetted. The parapets, about eight feet thick, and seven feet six inches in height, were formed of layers of fern mixed with earth. The advantage of this mode of construction was seen during the attack on No. 3 Redoubt, where the enemy's storming party, after gaining access to the ditch unperceived in the darkness, found themselves unable to clamber over the parapet, in consequence of the yielding nature of the mixture of earth and fern, in which they could not get a foothold. They then endeavoured to demolish it by pulling out the fern, but the interlacing of its branches inside the parapet, with the weight of the superincumbent earth, frustrated their efforts.

The accompanying map (Plate I.) shows the lines of sap and the positions of the various redoubts.

The sap, both double and single, was constructed in the usual manner with sap rollers and gabions, but, the supply of the latter being limited,

* *Phormium tenax.* The leaves are five or six feet long and two or three inches wide, containing a great quantity of very strong fibre.

the gabions were removed from the rear as the work advanced, and a revetment of fern and earth substituted. Thus, whilst the whole of the work remained secure, a sufficient stock of gabions was always kept on hand to push forward the head of the sap.

The opinion has often been expressed that the settlers, if left to themselves, would be able to defend themselves better than the troops could do it for them. This opinion appears to be founded on the example of the old Dutch settlers at the Cape, and the English in North America.

In both these cases the colonists had in the first instance the immense advantage of using firearms against tomahawks, spears, or bows and arrows. Every house was a little fort, and every man's rifle his constant companion. Thus, before the introduction of fire-arms amongst the natives made the terms more equal, the settlers had gained a prestige and a sense of superiority which they never entirely lost.

In New Zealand the case is entirely different. It is true that the whalers, sealers, and runaway sailors of former days, men accustomed to a life of vicissitude and hardship, prompt to strike on small provocation, and endowed with means of offence and defence which the Maories did not then possess, were able to make themselves respected. But the present race of European settlers in New Zealand is altogether different in character. At the close of Heke's war the European population of the islands was barely 13,000, of whom but a very small number had taken any part in the military operations. At the commencement of the recent war the number had increased to about 60,000,* almost wholly by immigration from the United Kingdom.

During this interval of more than twenty years, many of the Maori tribes had been engaged in constant wars amongst themselves, whilst the settlers had enjoyed profound peace. The result was, that the Maories never lost their knowledge of the art of war, whilst the Europeans, who were originally ignorant of it, never learned it. In short, they were very like people of their class in England, excellent material for soldiers, fine "food for powder," but altogether destitute, generally speaking, of the special qualifications for guerilla warfare which they were commonly supposed to possess. Game is scarce in New Zealand, and there is little inducement for men to acquire the habit of using firearms. At New Plymouth consequently, where the adult male population was scanty, the women and children comparatively numerous, where no facilities for defence existed, where there was not even a port by which communication by sea with the other settlements could be secured, and where the people, who were generally quiet peaceable agriculturists or tradesmen unaccustomed to war, were surrounded by half-savage enemies brought up from childhood to skirmishing and the use of fire-arms, I have no hesitation in saying that the place could not have been held without the presence of a large body of troops.

There can be no doubt that the military qualities of the Maories, whilst they have been greatly overrated by themselves, have been equally underrated by Europeans. It was a generally received opinion among the settlers, not only before the recent war, but for some time after its commencement, that, however expert the Maories might be in building pas

* See Appendix (B).

and constructing other works of defence, they were too timid to adopt offensive operations, and that they would never venture to attack a military post. I cannot find that there ever was any ground for such a supposition. On the first occasion on which the Maories met the troops (the attack on Korarareka in 1845) the former were the assailants. In the war near Wellington they were almost always so, and at Wanganui in 1847 they repeatedly attacked the stockades in which troops were posted.

In the recent war also, their well-planned and most gallant assault of No. 3 Redoubt, as well as their repeated attacks upon the head of the sap, have shown that when occasion requires it they want neither courage nor capacity to undertake offensive operations even upon a considerable scale.

Their habitually defensive tactics, instead of being due to timidity, are really proofs of sound judgment and good generalship.

The attack on No. 3 Redoubt was caused by their finding themselves in the presence of a commander whose tactics were superior to their own, and whom they could not induce to fall into their trap, or to lead his men up to their fastnesses to be shot down helplessly and unavailingly, as had been done on more than one previous occasion.

The enemy were much more ready than the British public to acknowledge the ability with which the attack against them was conducted. In the former war, whilst admiring the bravery of the troops, they regarded the tactics of our commanders with contempt and derision. They now say that General Pratt is "tohunga," which means a master of his art or calling; and they confess that they were confounded by the operation of the sap, and that its slow, but certain and irresistible advance, wearied, depressed, and disheartened them.

Towards the close of the operations an altered tone began to be perceptible even in the colonial press, which had previously been loud in vituperation of the general and troops, and, as I am not aware that any answer has been given in England to the ignorant and unfounded depreciation with which "The Times" was in the habit of speaking of the behaviour of the troops, perhaps I may be permitted to quote one or two short extracts from colonial papers. The correspondent of the "Taranaki News," writing from the Waitara on the 21st February, 1861, speaking of the country about "Te Arei" pa, says—

Beyond is a grand semi-circle of hills and tremendous gullies. One noble hill, which commands the whole on our extreme left, sloping off thence to the valley, is partly cleared; but the remainder is clothed in a beautifully variegated skirt of dwarf bush, amongst which the graceful mamaku is very prominent. The fern and dwarf bush on the other hills have been partially burned by the retreating enemy, that it might not afford a cover to our approach; and the summit of every hill from left to right, a distance of not much less than a mile, appears to be one range of rifle-pits. If I have succeeded in conveying any idea of our position, it will be seen that the vantage-ground still belongs to our pertinacious and resolute enemy. Under a desultory fire, which happily has not yet much harmed us, although continued with but small intermission from daybreak to dusk, our brave fellows have been labouring somewhat slowly from the last week's bad weather, but surely approaching the fastness of the Maori; but there is no hope of our being able to move with the celerity, promptitude, and all-subduing energy of those gentlemen who conduct their warlike operations in theory from an easy chair. The more we see and learn of the obstinate enemy in our front, the greater the difficulties appear in the prosecution of the struggle in which we are engaged to a

successful issue. Do not misunderstand me. I write not this in a desponding spirit; for with the above assurance increases our confidence in the master spirit directing matters here.

A Melbourne newspaper in April, 1861, published the following very just observations:

It is most instructive to observe that the forces in New Zealand have gained their successes just by the very means which have been ridiculed by our colonial amateurs and by "The Times." The general was slow and regular in his movements,—the amateurs were all for energy and dash. According to "The Times" and his imitators, savages, forsooth, have learnt "to despise regular warfare;" and it appears that we have the best weapons, but do not know so well as the savage how to put them to the best use. "The consequence is," says "The Times," "that we retire in discomfiture before foes whose superiority, although they are savages, actually lies less in numbers than in wisdom. If the Maories had borrowed our shakoes and pipeclay, and drawn themselves up in line to receive our attacks, we should laugh at their folly. Unluckily it is we who show ignorance of the conditions of fighting, and the laugh is on the savages' side." We question whether there is, even in the lucubrations of the colonial press, anything so excessively absurd as the above, which in fact is probably unsurpassed in the annals of literary or military criticism.

The self-evident folly of the statements renders all commentary superfluous; but it is only justice to the gallant general to quote the following remarks by one of the repentant sinners who wrote some of the reports which doubtless misled "The Times." The remarks are those of the correspondent of a Taranaki newspaper, and refer to the attack on the last Maori stronghold:—

"It is only when one has seen this position that he can appreciate the cautious manner in which the general has approached it. Most of the troops have often expressed it as their ardent wish to take it by a charge, and your correspondent always thought it the best and safest plan till to-day; but I now perceive, that, to have charged this position, would have been like ordering brave men to commit self-destruction. Even the natives, before they could find footing on it, were obliged to dig away a narrow strip from the brink, thus forming a ledge for themselves to stand on; and even this shelf is so narrow that not more than one row of men in single file can occupy it. Therefore a line of soldiers charging it must, in their eagerness to meet their foes, either fall over the precipice and be dashed to pieces in the shallow river beneath, or, what would be as bad, they would have to retire defeated before the destructive fire of an exulting foe. Neither could an attack in flank be ventured upon along this ridge, as only one man could advance at a time. It follows, therefore, that whatever might be won by charging an enemy on ground presenting but ordinary difficulties, to order a rush on such a position as this would be universally denounced as wilful murder, for the result could only be a terrible catastrophe. I make this statement, because truth prescribes it, in justice to a general whose plans have been too hastily censured."

All honour to General Pratt for the skill with which he has rooted out the savages from a line of defence of such unparalleled strength; but, in our humble opinion, his greatest glory consists in the firmness of mind he displayed, in disregarding the vituperations of his "civil" critics, and his perseverance in spite of all calumny in the despised system of regular warfare—a system which it is now clearly demonstrated could alone have been successful.

On a former occasion I expressed an opinion that the complete subjugation of the Maories would be a task little inferior in magnitude and difficulty to that of the Conquest of Britain by the Romans. In some respects it would be even more arduous. The difficulty of communication and transport, owing to the natural features of the country, would be infinitely greater than they can at any time have been in England, which nevertheless cost the Romans many a long year of hard work and hard fighting to subdue.

From the mountains of Scotland they retired baffled, and were even compelled to protect their territory in the south by immense entrenchments from the attacks of the wild tribes inhabiting the Caledonian Hills.

Moreover, the introduction of fire-arms has greatly diminished the superiority of regular troops over savages in a difficult country. The power which fire-arms have given them of projecting deadly missiles from invisible hiding places has immensely increased their facilities for resistance, and, as the country in the North Island of New Zealand becomes more and more impassable as you advance towards the interior, it would require extraordinary care and precaution to prevent an invading force from finding itself in a position from which to advance would be impossible, and to retreat disastrous.

Let us hope that it may never be necessary to undertake anything of the kind, not only on account of the enormous difficulty and expense which must attend military operations on a great scale in that country, but for the sake of the brave, high-spirited, and interesting race whose destruction would in all probability follow.

The British Government is now in a far better position to promote a durable pacification than it was at the close of the former war. At that time the Maories considered themselves with much show of reason to have been the victors in the contest, and they believed then, and continued to believe until very recently, that it was in their power if they chose to drive the whole of the European population into the sea.

The idea, once prevalent in England, of our superiority to the French, which found expression in the old saying,—"On every pair of English legs do march three Frenchmen," fell short of the opinion of their own prowess entertained by the Maories, who made no secret of their conviction that one Maori was equal to three soldiers in the fern and to nine in the bush. This flattering notion has now been rudely dispelled. They have learned by bitter experience the superiority of a comparatively small number of troops, when skilfully handled, even in positions peculiarly favourable to native tactics.

The Waikatos, the proudest and most powerful of the native tribes, now acknowledge the utter hopelessness of a contest with the power of England; but they would probably not shrink from war, even to the death, rather than abandon their rights of property in the soil.

It is easy to point out the absurdity of some 50,000 semi-savages requiring a fertile territory as large as Ireland for their support, but we can hardly blame the Maories if they take a different view of the question. They have much pride of race, combined with a full knowledge of the superiority in arts and civilisation of the Europeans. Although they probably do not suspect the British Government of any deliberate intention to treat them with injustice, they are very naturally alarmed by the rapidly increasing numbers and power of the colonists, which they cannot help associating in their minds with an impression of the impending downfall and dispossession of their own race. The possession of the land is the only means of safety that they see before them, and it is, perhaps, to be expected that they will cling to it with desperate pertinacity.

We are fortunately now in a position to practise conciliation towards them without being suspected of timidity, and we may treat with gentleness and consideration a high-spirited people, suffering under the humiliation of unwonted and unexpected defeat.

APPENDIX (A).

MILITARY FORCE in the province of TARANAKI, including Naval Brigade, Militia, and Volunteers, from June, 1860, to January, 1861.

Date.	Troops and Naval Brigade.	Militia and Volunteers.	Total.	Effective (about)	Remarks.
20th June, 1860 . . .	1188	573	1761	1500	
11th August, 1860 . .	1786	532	2318	2000	
10th September, 1860 .	1786	502	2288	2000	
3rd October, 1860. . .	1634	527	2161	1860	Half the Naval Brigade ordered to Auckland since last return.
12th November, 1860 .	1253	493	1743	1500	400 troops sent to Auckland.
10th December, 1860 .	1718	474	2192	1900	The troops sent to Auckland had returned.
1st January, 1861 . . .	1726	477	2203	1900	
28th January, 1861 . .	2460	522	2982	2600	Reinforcements of 14th and 57th Regiments arrived.

	Troops and Naval Brigade.	Militia and Volunteers.	Total.	
12th November, 1860, Garrison of New Plymouth, in all, amounted to . .	530	377	907	Non-Effectives included 126 Militia employed as boatmen, carters, butchers, and bakers, in New Plymouth alone.
Of whom Effective, about	455	226	681	
Non-Effective	75	151	226	

APPENDIX (B).

New Zealand.

Approximate Population in 1858.

European.

Northern Island	35,000
Middle Island	25,000
	60,000

Maori.

Northern Island	55,000
Middle Island	2,500
	57,500

Since that date the European population has probably increased to about 100,000; but this increase is mostly due to the development of Canterbury as a pastoral or "squatting" country, in competition with Australia, and to the discovery of the great goldfields of Otago, which have already drawn off many thousands of gold-diggers from Victoria and New South Wales. The increase therefore is chiefly confined to the Middle Island, where the Maories are insignificant in number.—C. P.

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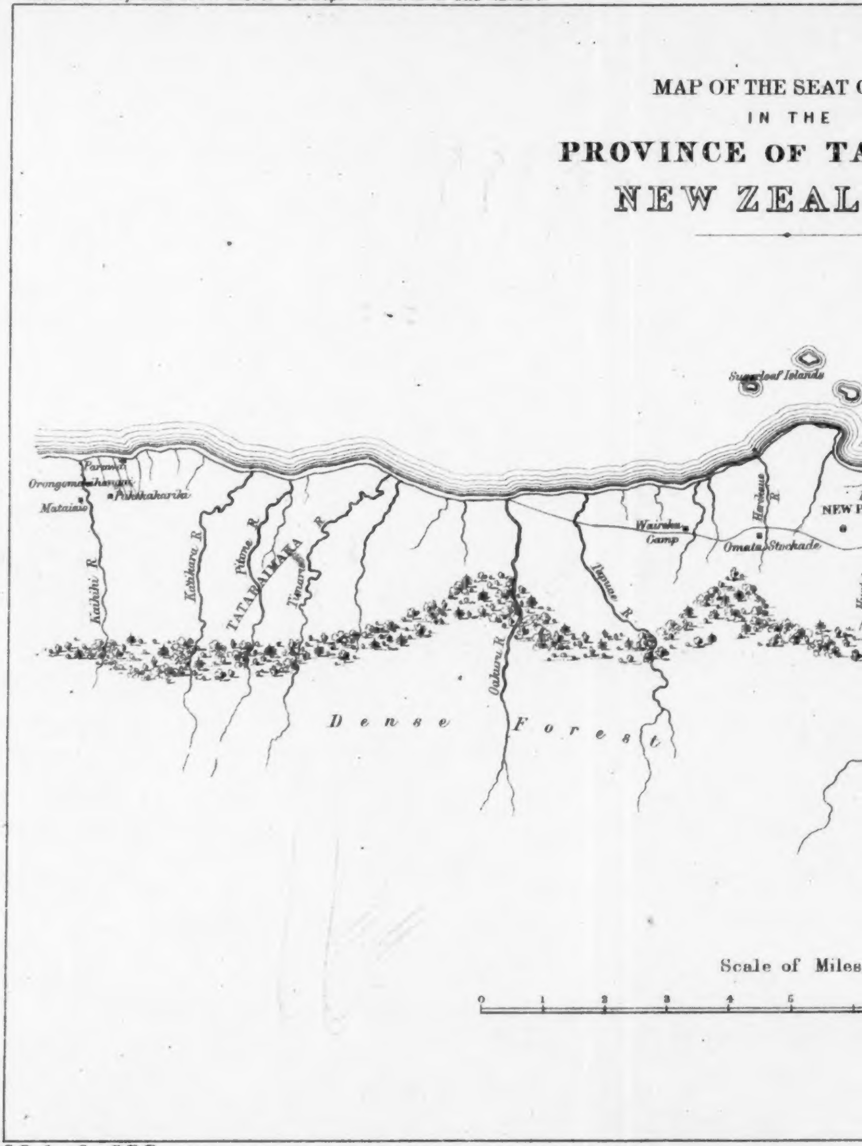
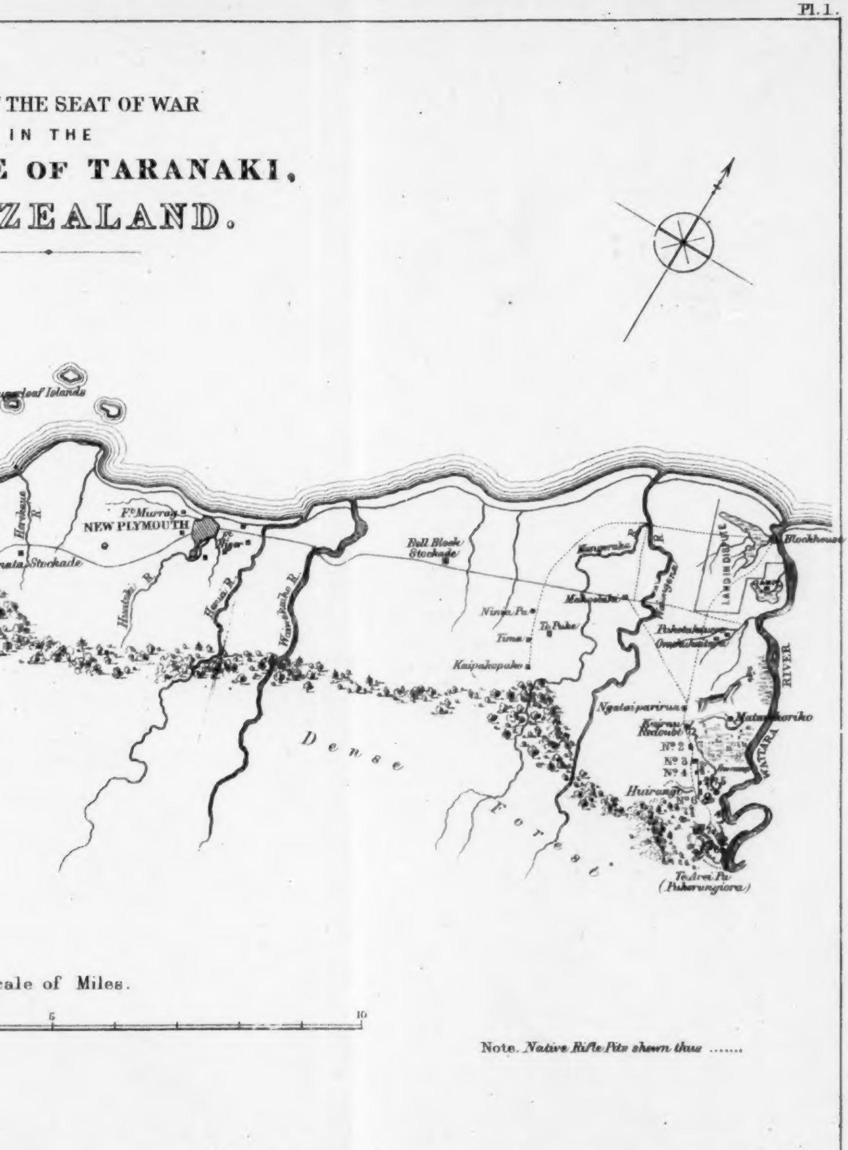
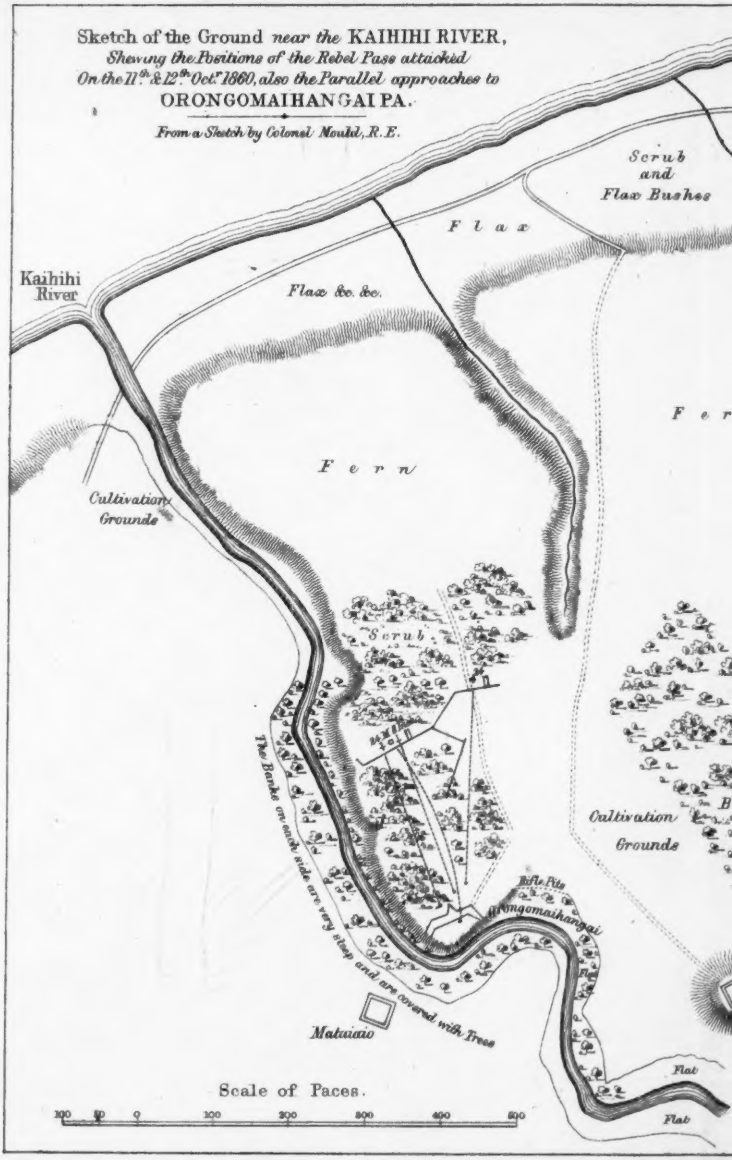
The Plates to be placed at the end of the Paper in the order of their numbers.



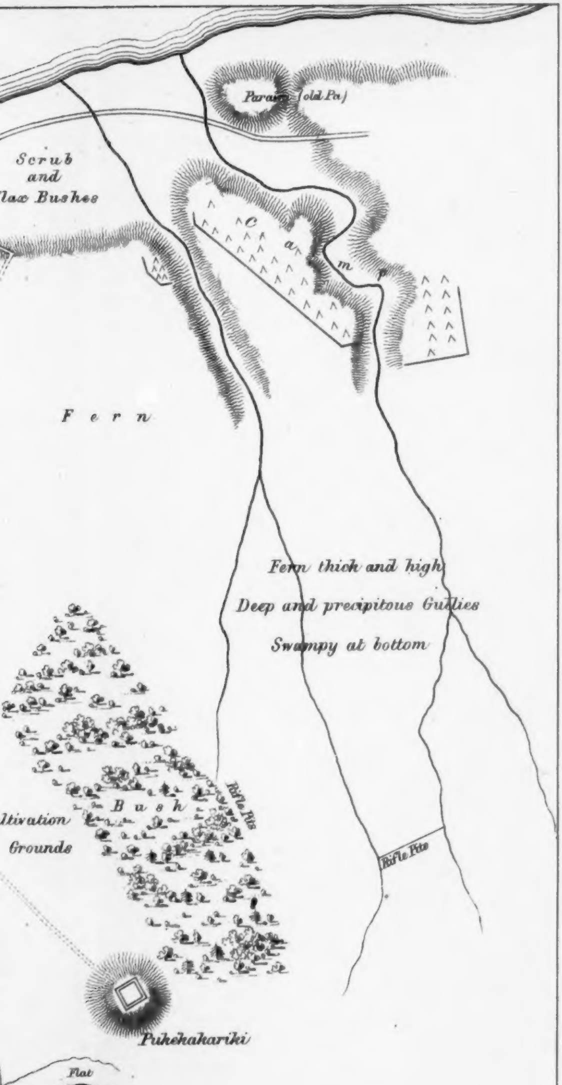
C. Pasley, Captn. R.E.


THE SEAT OF WAR
IN THE
OF TARANAKI,
ZEALAND.
NEW PLYMOUTH
Bell Block Stockade
Stockade
Blockhouse
WAITARA RIVER
Dense Forest
Huirangi
No 2
No 3
No 4
No 6
Te Arei Pa
Ngataiparirua
Ninia Pa
Te Puke
Tima
Kaipakopako
Waiwakaiho R.
of Miles.
5
10
Note. Native Rifle Pits shown thus ....

J.R.Jobbins.


Sketch of the Ground near the KAIHIHI RIVER,
Shewing the Positions of the Rebel Pass attacked
On the 11th & 12th Octr 1860, also the Parallel approaches to
ORONGOMAIHANGAI PA.
From a Sketch by Colonel Mould, R.E.
Scrub and Flax Bushes
Flax
Kaihihi River
Flax &c. &c.
Fern
Cultivation Grounds
Scrub
Rifle Pits
Orongomaihangai
The Banks on each side are very steep and are covered with Trees
Mataiaio
Cultivation Grounds
Flat
Flat
Scale of Paces.
100 50 0 100 200 300 400 500

Pl. 2

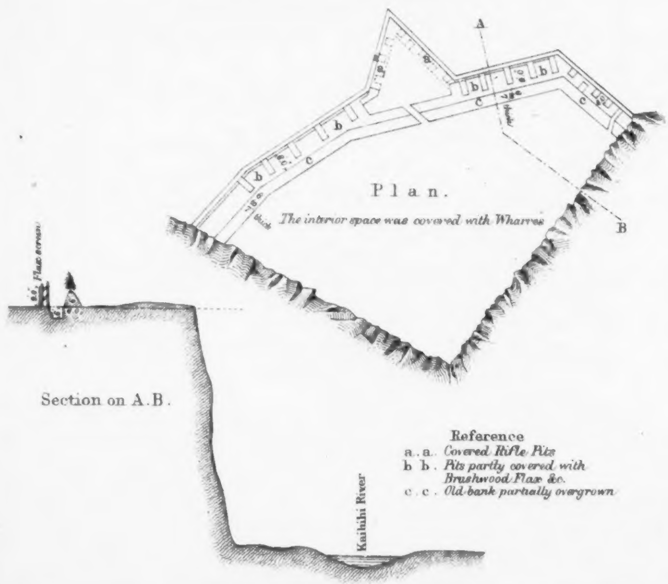


J.R.Jobbins

PLAN AND SECTION OF ORONGOMAIHANGAI PA,

Captured on the 12th October 1860.

From a Sketch by Colonel Mould, Royal Engineers.



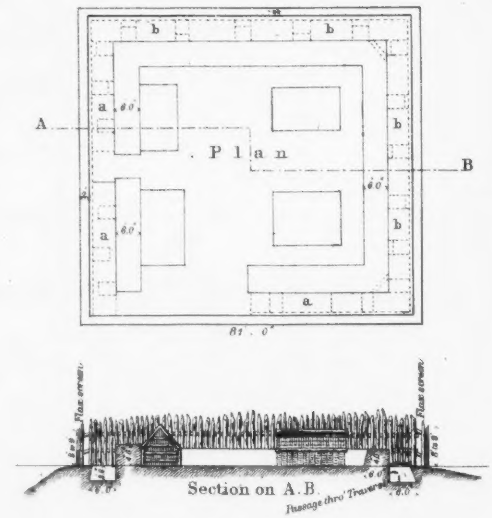
Reference

a. a. *Covered Rifle Pits*
b. b. *Pits partly covered with Brushwood Flax &c.*
c. c. *Old bank partially overgrown*

SKETCH OF PUKEKAKARIKI PA,

Destroyed on the 12th October 1860.

From a Drawing by Colonel Mould, Royal Engineers.



Reference.

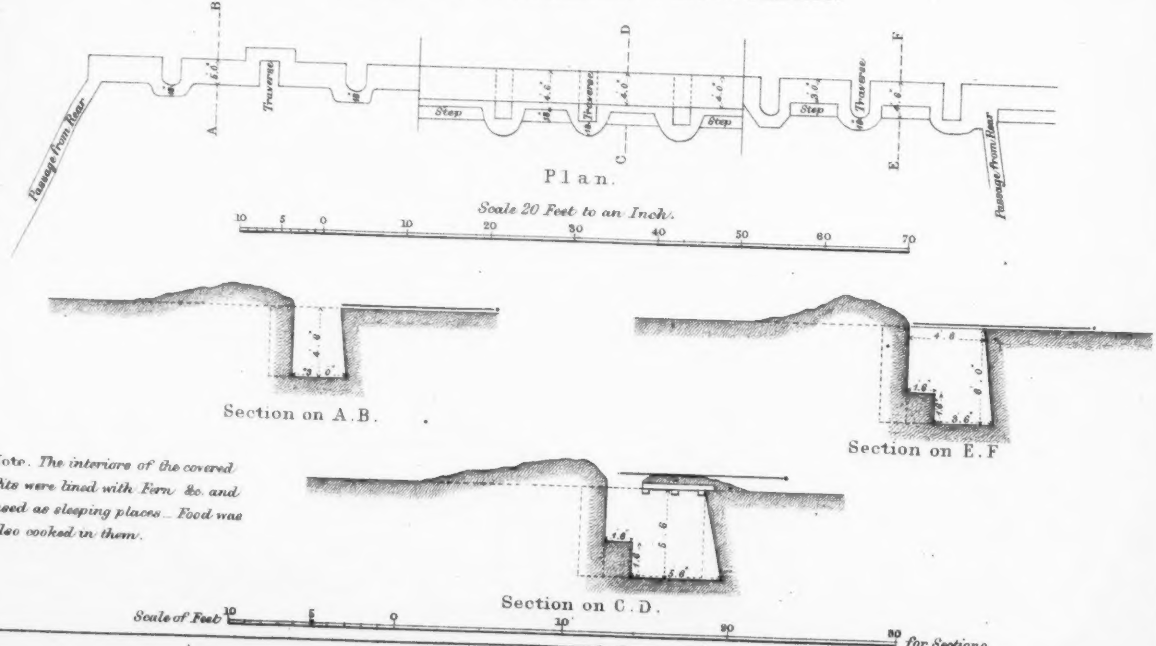
a. a. *Rifle Pits*
b. b. „ „ *covered with small Timber, Flax & Raupo*

Pl. 3.

J.R. Jobbins.

SKETCH.

EXPLANATORY OF THE CONSTRUCTION OF MAORI RIFLE PITS.



Note. The interiors of the covered Pits were lined with Fern &c. and used as sleeping places. Food was also cooked in them.

Pl. 4.

J.R.Jobbins.

DESCRIPTION OF A SERVICEABLE FIELD WORK—THE OMATA STOCKADE, TARANAKI, NEW ZEALAND.

Communicated by COLONEL SIR J. E. ALEXANDER, K.C.L.S. 14th Regiment, Feb. 21, 1862.

THE Maorie war of 1860–61 was a series of combats against an enterprising, active, and cunning foe, armed with double and single barrelled guns, tomahawks, and "merès" or flat clubs, fighting under every advantage in their native fastnesses and fern-clad plains, and, when worsted or tired, retreating into their entangled forests.

The Maorie combatants and our regular soldiers, the naval brigade, also the militia and volunteers, did their best for victory, dug trenches, constructed stockades, and plied the rifle, and our artillery their terrible great guns, for twelve months. The danger was considerable, and the work was hard; and, by-and-by, all this will be fully appreciated, and, doubtless, rewarded as Cape wars were. From personal experience we could judge of both seats of war.

An expedition south of New Plymouth laid waste some part of the lands of the Ngatizuanuis and Taranakis, who had surprised and slain five of our people, after martial law, but not war, was proclaimed, in consequence of the Ngatiawas obstructing the survey of the purchased block of land at the mouth of the Waitara. The Taranaki settlers, becoming alarmed, retired from the country into New Plymouth, and the southern natives then burnt the farm-houses, captured the horses, cattle, and sheep, and laid waste the province of Taranaki. The incidents of this interesting war are recorded elsewhere; suffice it here to say that the Maorie stronghold at Te Arei, or Pukerangeora, being about to fall by means of a well-executed sap directed by Colonel Mould, R.E., and the combined fire of great guns and rifles, the Waikato contingent, tired of the combat, withdrew to their own country, and the Ngatiawas hoisted a flag of truce to prevent their sacred or "tapued" burial-ground at Pukerangeora being violated. I took advantage of the white flag, and rode about to observe and note what might be useful afterwards to communicate.

I found at the Omata stockade, on a conical hill four miles south of New Plymouth, an intelligent and active militia officer, Captain George Rutt Burton; he had constructed his place of strength as "a city of refuge" for the neighbouring settlers, and from whence the enemy's foraying parties could be assailed as opportunities offered. I was much pleased with what I saw at Omata, and I obtained from Captain Burton the particulars of the construction of his stockade (he being his own engineer); and, as these may be of service to officers in other fields of strife, I now give them in detail, accompanied with a sketch:

Fig. 1 shows a view of the outside of the stockade, taken from the foot of the slope on the north side of the building.—The ditch, as shown here, surrounds the stockade, the outer edge or counterscarp being distant on an average about thirty-two feet from the outside of the stockade. Its form is an oblong. A section of it is shown in fig. 3.

Rough wooden steps lead from the drawbridge to the entrance gate. The drawbridge has a span of ten feet, and works upon strong hinges at the end nearest the gateway. It is constructed so as to be as light as possible, consistent with the requisite strength for bearing the ordinary traffic and the provisions, &c. which had to be taken across it. By ropes fastened to its front edge, and running through blocks on the top of the inner posts, it is elevated at night to a perpendicular position, thus serving to prevent ingress or egress. A light moveable handrail on each side (withdrawn at night) prevents accident in crossing the bridge.

It will be seen that the bastions are of two stories each, being loop-holed on all four sides of both stories. The lower part of each is a sleeping apartment. The upper is the post for the sentries at night and in bad weather.

The roof of the bastion is raised clear of the wall-plate, and is made to project a foot, or rather more, beyond the wall of the building. This arrangement admits of the sentries keeping a good look-out all round, yet protects them, to a great extent, from the weather; and further, allows of firing through the space between the roof and the wall-plate, when more convenient to do so (as was often found at long ranges) than through the loopholes. The other parts of the building have a single row of loopholes only. The roof of the sides and ends of the building is made to project about a foot beyond the outside, so as to make it extremely difficult to scale.

The entrance-gate is made of two thicknesses of "heart of pine" timber, each 2½ inches thick, the outer running up and down, the inner diagonally, and strongly nailed together with spike nails, rivetted. It forms a solid door five inches thick. The jambs and sills, of heart of pine, are 12 inches by 9 inches. The jambs are sunk 5 feet into the ground; the whole framed together and well fastened to the building on each side. The hinges form, at the same time, the fastening to the gate; they are stout iron bands, extending across the door, and fitting over a staple with an eye (driven into the door-jamb), and are there secured by dropping an iron pin through the eye.

The signal staff is erected outside, but worked from within the building. It is one single young tree 60 feet long, sunk 6 feet in the ground, and properly secured by stays, guys, &c. The yard is 24 feet long. The signal balls are of wicker covered with canvass. There is an easy code for using them.

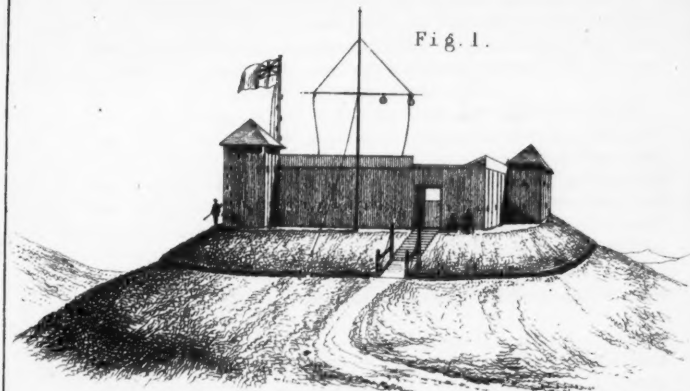
The small staff is quite unconnected with signals, and is for a British flag.

Fig. 2 shows *Ground-plan*.—The stockade is on the site of an old native war pah, called Nga-ture, or "the knees." The situation being that best fitted of any in the district for a post, it was necessary to adapt the building, both as to dimensions, mode of construction, and other matters, to the local circumstances.

The outer part is constructed either of trunks of small trees entire, or

To face page 596.

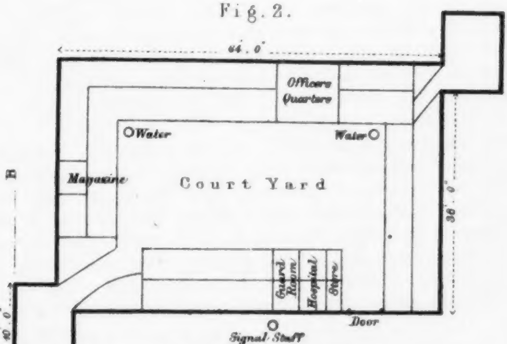
Fig. 1.



J. E. A. From a Sketch by T. Good, Ens. T. M.

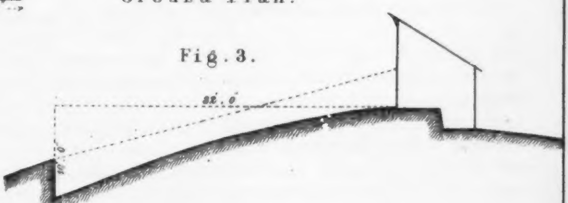
PERSPECTIVE VIEW OF THE OMATA STOCKADE, TARANAKI, N. Z.

Fig. 2.



Ground Plan.

Fig. 3.



Section on Line A. B.

Shewing Slope in front of outside of Stockade.

J. R. Jobbins.

split portions of large ones, mostly the former. These piles are sunk into the ground about 3 feet 6 inches, and stand 10 feet out perpendicularly. The piles were roughly trimmed down with the axe, so as to bring them together as closely as practicable, and any knots or excrescences removed from the outside, which otherwise might facilitate scaling.

The slight apertures unavoidably left between the logs were filled up by placing an inner row of stout slabs perpendicularly, covering the gaps and leaving no openings. The logs were all sawn off straight in the bush, to bring them to a tolerable level at top. To bind the whole together and make it firm, sawn battens, 6 inches broad by 3 inches thick, were laid along the top, and a 7-inch spike nail driven through into the head of each pile. The thickness of the piles varied a little, but the average thickness might be taken at 12 inches.

The whole was proof against musket balls, and nearly so against rifle balls, except at a very short range.

The soil was removed from that portion which is marked in the ground-plan as "Court Yard" to the depth of 3 feet, so as to admit of sufficient fall for the roof, which slopes inwards from the top, as shown in a section on the margin of the ground plan. The roof is framed in the ordinary manner, of sawn timber, covered with roof-boards and shingled.

That portion of the interior where the magazine is situated has solid natural earth, extending inwards six feet from the piles of the stockade. Round the remainder of the building the earth was removed to within three feet of the piles, thus leaving a vacant space of three feet under the sleeping-places for accommodation for the men's clothes, for fuel in the guard-room, &c. The floor on which the men's bedding was laid at night was laid upon joists, and boarded six feet inwards from the piles, leaving a vacant space of four feet at the foot of the respective beds (and of course about two feet six inches lower, being, in fact, only a few inches above the level of the court-yard), for passage and access to the sleeping-places. The loopholes were cut at such an elevation as enabled the rifles to be worked clear of the roof, and also that the men standing on the boarded floor covered any object down to the bottom of the ditch, as well as from the external edge of the ditch, down the glacis, and everywhere round the stockade. Whatever the weather, the men of course were firing under cover. No man could approach the stockade under cover, even though on his hands and knees.

Doors admit from the yard to the different portions of the building, and small windows looking into the yard (and made to fasten open for ventilation in summer) afford the requisite light.

For a militia force composed of persons of all classes of society, the break in the sleeping apartments caused by the intervention of the officers' room, commissariat store, &c. &c., is a great advantage, as allowing more classification and greater privacy than if the whole were in one large undivided room. It gives also more comfort and warmth, both very much needed in an exposed position and rough building. The inner face of the piles, forming one wall of the sleeping apartments, is covered with coarse canvas and papered. This was done by the men at their own expense, and for their own comfort, the cost to each being very trifling. Previously to fastening the canvas, the crevices were stuffed with waste wool,

old woollen garments, or other uninflammable material, so as to exclude wind.

A sort of rack was formed under the roof, so that in the event of sudden alarm at night each man could spring up at once, seize his rifle from over his head, and commence firing, if required, without waiting to dress.

As regards the plan of the building generally, there are many points in which alterations could be made. When deliberately made, it could probably be done cheaper; but this was built in an emergency, without engineering assistance, and with an enemy daily expected; in fact the fight at Waireka took place when the officers and men were entirely without sleeping accommodation and the outer gate of the building was not completed.

Captain Burton was necessitated to adapt his arrangements from time to time according as he could or could not get timber or other articles required. The bastions would be better if three feet larger each way, but the nature of the ground would not admit of it in this case.

Local circumstances influenced the selection of the position for the gateway, otherwise it would be more completely commanded if placed nearer to a bastion.

The commissariat and other stores would be better all together, but, in the first instance, a short supply of rations was kept on hand, and subsequently, when required to keep forty-five days supply of flour, biscuit, rum, candles, fuel, and a quantity of salt meat, besides having to find store room for provisions left there to be forwarded to the Camp on Waireka Hill (under Major Hutchins of the 1st battalion of the 12th Regt.), Captain Burton was compelled to increase the accommodation.

No provision was made for cooking in the stockade, as there were three dwelling-houses within a few yards of the foot of the hill which were occupied by day as mess-houses. For the same reason no well was sunk, and the garrison would have required to dig at least 120 feet. Having plenty of biscuit it could not starve, and three large casks of water were always kept in the yard for the convenience of the men, and in case of fire at night.

The number of men at the post has varied from fifty-four to seventy-three; and, excepting at one time, when for a few weeks twelve artillery-men were stationed there (their two guns being dismounted and packed away in the yard by order of Colonel Gold), the place has always been garrisoned, as it was constructed, by militia and volunteers.

As to the cost of the stockade, it is difficult to give correct information, but the following may be of some service.

The whole of the trench-work, sloping off the earth down to the level at foot, the whole of the work on rough timber, splitting and putting on the shingles, and, in fact, everything but the actual carpenters' work on sawn timber, was done by the men themselves, providing their own tools, and receiving nothing but the ordinary pay and rations. For cartage of the rough logs and sawn timber payment was subsequently made. It was equal to eighty-four days' labour for one cart and pair of oxen. The rough timber was carted about 2½ miles. The sawn timber used amounted to 10,000 feet. This, and the windows, latches, hinges, nails, tacks, &c. &c. was also paid for. It is easily estimated.

The carpenter's work was executed by men belonging to the detachment, and they received extra pay 1*s.* 3*d.* a day, as per regulation. The number of days paid for at that rate was equal to 241 for one man.

The tackle for the signal staff was provided by the Royal Engineers department, but all put up by the men.

As it was never contemplated that anything but small arms would be used, no arrangements were made for artillery ; but with larger bastions a small piece in each would of course completely sweep the sides.

I may add, that, as an additional defence (and an excellent one) to his stockade, Captain Burton said he turned three dogs loose into the ditch every night. For want of dogs I had caused broken bottles to be thrown into the ditch of a blockhouse elsewhere, as the sturdy lower limbs of the Maories are generally unprotected.

Pokeno Camp, Waikato, N.Z.